**NATURAL RESOURCES CONSERVATION SERVICE**

**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.

## PURPOSE

This practice may be applied as part of a conservation management system to support one or more of the following purposes to:

- Stabilize the grade and control erosion in natural or artificial channels
- Prevent the formation or advance of gullies
- Improve water quality

## CONDITIONS WHERE PRACTICE APPLIES

Areas where the concentration and flow velocity of water require structures to stabilize the grade in channels or to control gully erosion.

## CRITERIA APPLICABLE TO ALL PURPOSES

All planned work shall comply with all Federal, State, and local laws and regulations. The strictest requirements shall be used.

The designer shall determine if the planned dam will be regulated by the Tennessee Safe Dams Act of 1973 as amended. If regulated, any State requirement stricter than NRCS requirements shall be used. Design and construction of any regulated dam will require the advance written approval of the State Conservation Engineer.

**This conservation practice is exempt from receiving coverage under TDEC's (Tennessee Department of Environment and Conservation) ARAP permits. This exemption allows this conservation practice to be installed adjacent to streams and plan for the outlet of the structure to be placed down through the stream channel bank and into the closest edge of the stream channel. The TDEC ARAP exemption does not change the permitting requirements for the U. S. Army Corps of Engineers permits (404), the Tennessee Valley Authority permits (26a – if located within the Tennessee River drainage area.), or any permits that may be required by local units of government.**

**The exception to the TDEC ARAP exemption described in the previous paragraph is where the conservation practice is planned to impound the stream or directly impact the stream channel. If this conservation practice is planned on a stream, then it is no longer exempt from the ARAP process. If planned on a stream, these conservation practices are required to apply for and receive U. S. Army Corps of Engineers permits (404), Tennessee Department of Environment and Conservation permits (ARAP), Tennessee Valley Authority permits (26a – if located within the Tennessee River drainage area.), and any permits that may be required by local units of government. All conditions listed within the permits shall be followed during the installation of the practice.**

Special attention shall be given to maintaining or improving habitat for fish and wildlife where applicable.

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

Conservation practice standards are reviewed periodically and updated if needed. To obtain the current version of this standard, contact your Natural Resources Conservation Service State Office or visit the Field Office Technical Guide.

**Earth Embankments**. Low hazard class dams that have a product of storage (acre-ft.) times the effective height (ft.) of the dam of 3,000 (acre-ft$^2$) or more, those more than 35 ft in effective height, and all significant hazard class and high hazard class dams shall meet or exceed the requirements specified in Technical Release No. 60, “Earth Dams and Reservoirs” (TR-60).

Low hazard class dams that have a product of storage times the effective height of the dam of less than 3,000 (acre-ft$^2$) and an effective height of 35 ft or less shall meet or exceed the earth embankment requirements (geologic investigation, top width, freeboard, foundation cutoff, slope protection, etc.) as specified in NRCS conservation practice standard Pond, Code 378.

The effective height of the dam is the difference in elevation in feet between the auxiliary (historically referred to as emergency) spillway crest and the lowest point in the cross section along the centerline of the dam. If there is no auxiliary spillway the lowest point on top of the dam is the upper limit.

Earth embankment and auxiliary spillways of structures for which criteria are not provided in 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 required total capacity without overtopping the embankment. The foundation preparation, compaction, top width, and side slopes must ensure a stable embankment for anticipated flow conditions. Discharge from the structure shall be sufficient that no crop damage results from flow detention.

The diameter of the principal spillway pipe shall not be less than 4 inches. Any pipe conduits used solely as a supply pipe through the dam for watering troughs and other appurtenances shall not be less than 1-1/4 inches in diameter.

The minimum capacity of the principal and auxiliary spillways 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. The auxiliary spillway capacity may be further reduced for creditable principal spillway discharge. If the storage capacity is more than 50 acre-ft., use the 24-hour duration design storms of the frequency shown in Table 1 less any reduction from detention storage or principal spillway capacity as appropriate.

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-ft., shall be designed to control the 10-year frequency storm without overtopping. The mechanical spillway, regardless of size, may be considered in the design and an auxiliary spillway is not required if the combination of storage and mechanical spillway discharge will handle the design storm.

The combined side slopes of the settled embankment shall be not less than 5 horizontal to 1 vertical (5:1), and neither slope shall be steeper than 2 horizontal to 1 vertical (2:1). In highly erodible soils, consideration shall be given to flattening the slopes to 3 horizontal to 1 vertical (3:1) with the combined slopes being 6. All slopes shall be designed to be stable. Where embankments are to be mowed; 3 horizontal to 1 vertical (3:1) or flatter slopes are recommended.

Compaction of the embankment fill material shall be in accordance with the specified design requirements for compaction and moisture content. Maximum thickness of earthfill layers will be 9 inches. If for any reason the designer is of the opinion that more stringent compaction requirements are necessary, percent of standard proctor and moisture limits may be specified.

The design height of the embankment shall be increased by the amount needed to ensure that after settlement has taken place, the constructed height of embankment will equal or exceed the design height. This settlement shall not be less than 3 percent for rubber-tired pans and scrapers and 5 percent for track type equipment such as bulldozers, except where detailed soil testing and laboratory analysis show a lesser amount is adequate, or field observations indicate a greater amount is needed to obtain the needed level of compaction.

**Table 1**. Design criteria for establishing minimum capacity of the principal spillway and auxiliary spillways for dams with storage capacity of less than 50 ac-ft.

| Drainage Area | Effective Height of Dam | Storage | Principal Spillway - Minimum 24-Hour Duration Frequency Design Storm | Auxiliary Spillway - Minimum 24-Hour Duration Frequency Design Storm |
|---|---|---|---|---|
| *acres* | *feet* | *acre-feet* | *year* | *year* |
| 20 or less | 20 or less | < 50 | 2 | 25 |
| 20 or less | > 20 | < 50 | 5 | 25 |
| > 20 | > 20 | < 50 | 5 | 25 |
| >20 | >20 | > 50 | 10 | 50 |
| | | | | |

**Full Flow Open Structures**. Straight drop spillways, drop boxes, chute spillways, and box inlet drop spillways shall be designed according to the principles set forth in the NRCS National Engineering Field Handbook Part 650, the National Engineering Handbook, Series 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 less any reduction from detention storage and 100 years less any reduction creditable to principal spillway discharge and detention storage for the total capacity.

Structures must not create unstable conditions upstream or downstream. Provisions must be made to ensure safe reentry of bypassed flows.

Toe wall or wire panel drop structures can be used if the vertical drop is 4 ft or less, flows are intermittent, downstream grades are stable, and tailwater depth at design flow is equal to or greater than one-third of the height of the overfall unless the hydraulic design properly addresses less tailwater.

The ratio of the capacity of drop boxes to road culverts shall be as required by the responsible road authority or the capacity specified in Tables 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.

Structures with flashboard risers shall be designed to handle the design discharge with the water surface below the crest of the auxiliary spillway with all the flashboards in place.

**Island-type structures.** If the mechanical spillway is designed as an island-type structure, its minimum capacity shall be equal to or greater than the capacity of the downstream channel. For channels with drainage areas of 40 acres or less, the mechanical spillway shall have the minimum capacity of removing the runoff from a 2-year, 24 hour storm in 24 hours or the design drainage curve runoff. The minimum auxiliary spillway capacity shall be that required to pass the peak flow expected from a design storm of the frequency and duration for total capacity shown in Table 2, less any reduction creditable to principal spillway discharge and detention storage without overtopping the headwall extensions of the mechanical spillway. Provisions must be made for safe reentry of bypassed flow as necessary.

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

| | | Frequency of Minimum Design, 24-Hour Duration Storm | |
|---|---|---|---|
| **Maximum Drainage Area** | **Vertical Drop** | **Principal Spillway Capacity** | **Total Capacity** |
| *acres* | *feet* | *year* | *year* |
| 250 | ≤ 5 | 5 | 10 |
| 500 | ≤ 10 | 10 | 25 |

**Side-inlet Drainage Structures**. The design criteria for minimum capacity of open-weir or pipe drop drainage structures used to lower surface water from field elevations or lateral channels into deeper open channels are shown in Table 3. For all conditions shown in Table 3, the minimum principal spillway capacity shall be equal to or greater than the design drainage curve runoff. If site condition values exceed those shown in Table 3, the 50 year frequency storm shall be used for minimum design of total capacity less any reduction creditable to principal spillway discharge and detention storage. Provisions must be made to prevent damage from overtopping the structure and to divert excess flows away from the structure. On structures with drainage areas of 3 acres or less, overtopping of the structure is permitted only if damage will be minor and island type construction will interfere with normal farming operations.

Side-inlet structures with flashboard risers shall be designed to handle the design discharge with the water surface below the crest of the auxiliary spillway with all the flashboards in place.

Earth embankment side slopes shall be 2 horizontal to 1 vertical (2:1) or flatter on pipe island-type or side-inlet drainage structures as required for stability.

**Table 3**. Design criteria for establishing minimum capacity of side-inlet (open-weir or pipe drop) drainage structures.

| | | Frequency of Minimum Design, 24-Hour Duration Storm | |
|---|---|---|---|
| **Maximum Drainage Area** | **Vertical Drop** | **Receiving Channel Depth** | **Total Capacity** |
| *acres* | *feet* | *feet* | *year* |
| 250 | 0 - 5 | 0 - 10 | 1/ |
| 250 | >5 -10 | >10 - 20 | 10 |
| 500 | 0 -10 | 0 - 20 | 25 |

1/ Total capacity shall be equal to or greater than the design drainage curve runoff.

**Seepage Control**. Seepage control is to be included if (1) pervious layers are not intercepted by the cutoff, (2) seepage could create unstable swamping conditions downstream, (3) such control is needed to insure a stable embankment, or (4) special problems require drainage for a stable structure. Seepage may be controlled by (1) foundation, abutment or embankment filters and drains; (2) reservoir blanketing; or (3) a combination of these measures.

Seepage along pipes extending through the embankment shall be controlled by use of a filter and drainage diaphragm, unless it is determined by the designer that anti-seep collars will adequately serve the purpose. Anti-seep collars and drainage diaphragms shall meet the requirements of NRCS conservation practice standard for Pond, Code 378.

**Trash Guards**. Where needed to prevent clogging of the conduit, an approved type of trash rack shall be installed on the riser of drop inlets. Openings for trash racks shall be no larger than one-half of the barrel conduit diameter, but in no case less than 6 inches. The total cross-sectional area of the trash rack openings shall be equal to or greater than the area of the box or riser being protected.

**Antivortex Device**. Drop inlet pipe spillways shall be installed with an antivortex device where needed to prevent the formation of vortices. Antivortex devices shall be designed in accordance with ARS-NC-33, Hydraulics of Closed Conduit Spillways, Part XIV.

**Principal Spillway Outlets.** A non-erosive, stable pipe outlet shall be provided. Soil erodability shall be considered in the design of the outlet. Cantilevered outlet sections, if used, shall be designed to withstand the cantilever loading. Pipe supports shall be provided when needed. Other suitable devices such as a rock riprap stilling basin, Saint Anthony Falls stilling basin or impact basin may be used to provide a safe and non-erosive outlet.

**Other Outlets.** A pipe with a suitable valve shall be provided to drain the pool area if needed for maintenance or if required by State law. The principal spillway conduit shall be used as a pool drain if it is located where it can perform this function.

**Materials**. Structures installed under this standard shall be constructed of durable material with a life expectancy equal to the planned life of the structure. Pipe conduits, including cathodic protection as necessary, used in grade stabilization structures shall meet the requirements as stated in NRCS conservation practice standard for Pond, Code 378 except as allowed below.

High density polyethylene (HDPE) pipe conforming or to ASTM D3350 may be used for grade stabilization structures with a hydraulic head of 10 feet or less. The pipe exterior shall have annular corrugations. The polyethylene plastic shall be high density between 0.941 to 0.955 g/cm3; contain at least 2% carbon black but not more than 4%. The HDPE cell classification as specified in ASTM D3350 Section 4.3, Grade, shall be PE40 or PE42. Pipe joints shall conform to ASTM F2306, be watertight in accordance with a 10.8 psi laboratory test as specified in ASTM D3212 and utilize a bell and spigot design with a gasket meeting ASTM F477 or be plain end pipe using a watertight coupling system with a gasket meeting ASTM F477. Installation shall meet ASTM D2321 and the manufacturer's recommendations. Pipes and fittings shall be clearly marked as required by the applicable specification.

All HDPE risers shall be one piece construction. Pipe stubs shall be solidly welded to the riser and be watertight.

Concrete appurtenances used shall be designed for the anticipated loading. Concrete quality and construction shall meet the requirements of NRCS National Standard Construction Specification 32, Structure Concrete.

**Sediment Storage**. Necessary sediment storage capacity must equal the expected life of the structure, unless a provision is made for periodic cleanout and included in the operation and maintenance agreement.

**Safety**. 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.

Structures, earthfill, vegetated spillways, and other areas that are located in areas used for livestock or in urban areas should be fenced as necessary to control access and exclude traffic that may damage the structure as well as 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 sodden as necessary to prevent erosion. Areas shall be vegetated in accordance with NRCS conservation practice standard Critical Area Planting, Code 342.

## CONSIDERATIONS

Designs shall give serious consideration to providing partial height grade stabilization structures in channel stabilization situations. Bio-engineering, vegetated earthen slopes and other green stabilization methods shall be incorporated into hard stabilization projects, where possible, using biologically friendly products, designs and construction methods. Multiple alternatives shall be considered before selection of the chosen alternative. Designers may be requested by permitting agencies to justify the chosen alternative especially if it is a full height, hardened structure. See program policy for applicable restrictions to the lowest cost alternatives.

Where conditions preclude or make it difficult to establish vegetative cover, consider using non-vegetative coverings such as gravel, cellular confinement systems, gabions, interlocking blocks or other type of protection.

Grade stabilization structures with detention storage may affect the volume and rates of runoff, evaporation, deep percolation and ground water recharge as well as the movement of dissolved substances into the ground water.

Grade stabilization structures may trap sediment and sediment attached substances carried by runoff. Consideration should be given to the amount of sediment that will be deposited and allowances made for removal.

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.

The susceptibility of downstream streambanks to erosion and stream beds to aggradation or degradation should be considered in selecting the type of outlet and in determining the final grade of the outlet channel.

## 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.

## OPERATION AND MAINTENANCE

Operation and maintenance shall be in accordance with the requirements of this standard and in keeping in conformance with all local, state, and federal laws and regulations.

The grade stabilization structure should be inspected periodically to ensure that the structure functions as planned.

Inspect vegetation on all earthfills. Mow when vegetative growth becomes excessive. Repair and/or fertilize and lime damaged vegetation in accordance with NRCS conservation practice standard Critical Area Planting, Code 342. A soil test is recommended for determining the fertilizer and lime needs.

Inspect structures for deterioration and capacity. Remove any blockage of trash and debris that could affect flows through the structure. Repair or replace materials that have deteriorated, including rock used for outlet protection.

Inspect for safety of people or animals using the area near the structure.

Periodically remove sediment if storage is less than the expected accumulation during the design life.

## REFERENCES


- AASHTO M252, M294
- ARS-NC-33
- ASTM D1248, D3350
- National Engineering Handbook, Part 650, Engineering Field Handbook
- National Engineering Manual, Part 520, Subpart C - Dams
- NRCS National Engineering Handbook, Part 642, National Standard Construction Specifications Construction Contracts
- NRCS Conservation Practice Standards:
  - Critical Area Planting, Code 342
  - Pond, Code 378
- Technical Release No. 60, Earth Dams and Reservoirs