NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

GRADE STABILIZATION STRUCTURE

(No.)

CODE 410

DEFINITION

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

PURPOSE

The purpose of a grade stabilization structure is to stabilize grade, reduce erosion, or 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. 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 and shall meet the requirements specified for Pond (378) or Water and Sediment Control Basin (638) as applicable.

Conduits shall meet the requirements specified for Pond (378) or Water and Sediment Control Basin (638) as applicable. The pipe materials used shall be adequate for the intended design life 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.

If the structure has a permanent pool and the adjacent area is used for grazing or open to livestock, the pool area, earthfill, and vegetated spillways shall be fenced to exclude livestock. Where watering ramps are constructed to provide access to water in the pool, the fence shall permit livestock access to the ramp area only. 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. Fence materials and fence installation shall be as outlined in the standards and specifications for Conservation Practice Fence (382).

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. Side inlet structures installed where farming practices (such as rice fields) or drainage ditch maintenance prevents the establishment of permanent vegetation, the structure does not require seeding.

On sites located in cropland a minimum 50 foot wide strip of vegetation shall be installed around pool to filter out sediment.

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 ft in effective height, and all significant and high hazard dams must meet or exceed the criteria specified in Engineering Technical Release TR-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 ft 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 auxiliary spillway crest and the lowest point in the cross section along the centerline of the dam. If there is no auxiliary spillway, the top of the dam is the upper limit. For dams on existing roads or other sites without a measurable channel at centerline, the lowest elevation at the downstream toe will be used to determine effective height.

Overall height is the difference in elevation in feet between the lowest elevation in the top of dam (excluding the auxiliary spillway) and the elevation at the lowest point on the toe of the dam at the end of construction.

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.

Dams with an overall height of 35 feet or more shall meet the requirements of the Missouri Department of Natural Resources, Dam and Reservoir Safety Council.

Pond sized dams. 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. The minimum elevation of the top of the settled embankment shall be 1 foot above the water surface in the reservoir with the auxiliary spillway flowing at design depth.

Small pond-sized dams (Water and Sediment Control Basin-sized dams). For dams with an effective height of less than 15 ft and 10-year frequency, 24-hour storm runoff volume less than 10 acre-ft, 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. Design drop, chute, and box inlet drop spillways to the requirements in the National Engineering Handbook, 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. 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. 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.

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.

The structure should be a component of a water management plan. Other components may include Surface Field Ditch (607), Surface Main or Lateral (608), Structure for Water Control (587), or Irrigation Land Leveling (464). The

crest of the spillway must be set at an elevation that stabilizes upstream headcutting and provides adequate surface drainage for the drainage area.

Embankment side slopes shall be 3:1 or flatter on the upstream field side slope and 2:1 or flatter on the downstream side slope. Back slope may be steeper in order to match the existing receiving ditch side slope if it can be shown that the slope will be stable.

Conduits for pipe structures shall have a minimum diameter of 4 inches if a suitable trash rack is included and 15 inches if no trash rack is included and the drainage ditch is not likely to transport debris that would clog the inlet.

The conduit shall have a positive slope towards the outlet after consolidation occurs to ensure free drainage through the conduit. The conduit shall extend at least 1 foot beyond the downstream toe of the fill except that the conduit may extend less than 1 foot beyond the side slope of the embankment fill where it exits the slope if required to limit interference with normal operation and maintenance of the receiving channel. The invert of a pipe outlet shall be located between 0.5 and 1.0 feet above the normal static water level in the outlet channel or 1 foot above the channel bottom if the receiving channel is normally dry.

Cantilevered pipe outlets shall have pipe supports provided if the pipe strength is not sufficient to withstand the cantilever loading.

Where ditches flow bank full and design tailwater elevations are difficult to determine, then full pipe flow with 0.5 foot design head and submerged outlet conditions shall be used to determine structure capacity. The tables shown in the Missouri Supplements to the National Engineering (NEH) Part 650, Engineering Field Handbook, Chapter 3 may be used to determine capacity of structures using pipe spillways.

The flow capacity of a weir box inlet will be designed to equal or exceed the flow capacity of the pipe with a maximum water depth over the weir of 0.5 foot with the stoplogs installed to the planned stabilization elevation. Design must evaluate the buoyant forces acting on the inlet and pipe.

Smooth steel pipe may be used in any soil type and inlet configuration. Corrugated metal pipe (CMP) may be used in any soil but must be polymer coated when installed in soils that are rated moderate and high for risk of corrosion for uncoated steel; and CMP may not be used where weir box inlets are installed or may be installed in the future. Refer to the “Soil and Water Features” table in the appropriate Soil Survey for the county to determine the risk of corrosion.

An anti-seep collar shall be used on pipe structures installed in soils classified as SM according to the Unified Soil Classification System or in any soils that have demonstrated past seepage and washout failures. When needed, anti-seep collars shall be installed around the pipe conduit in the normal saturation zone.

Anti-seep collars and their connections to the pipe shall be watertight. The collar material shall be compatible with the pipe materials. The maximum spacing shall be approximately 14 times the minimum projection of the collar measured perpendicular to the pipe but shall not exceed 25 feet. Minimum collar projection is 1.0 foot. For design considerations, see Missouri supplement to the National Engineering Handbook (NEH) Part 650, Engineering Field Handbook.

If a side-inlet drainage structure outlets into a channel controlled by a legal drainage district, the top width of the embankment shall be that required by the legal drainage district or Pond Standard (378), whichever is greater.

The minimum length of the embankment fill to either side of the structure pipe shall be 3 times the total height of the fill or 10 feet whichever is greater. The elevation of the top of the settled fill shall meet the following criteria:

1. For structures on flat land where storage and/or auxiliary overflow width are unlimited, the top of fill shall be the highest of:
   a. 1 foot above the crest of the riser,
   b. 1 foot above the top of the conduit at the inlet,

      or,

   c. 0.5 foot above the elevation of the unlimited overflow area

2. For structures where the auxiliary overflow width is limited or where an auxiliary spillway is constructed, the top of the settled fill shall be at least 1 foot above the auxiliary spillway elevation.
3. For structures located in a permanent water management levee for a field, the minimum elevation of the settled fill at the structure shall be the top elevation of the existing field levee.

In all cases the depth of soil cover over the top of the conduit shall meet the requirements of National Engineering Handbook Part 650 (EFH) Chapter 14, MO-14-27 Appendix A.

Drainage gates shall be installed when required by state or local units of government. The connection of the gate frame to the pipe shall be watertight and compatible with the type of pipe used. Pipes with drainage gates shall be located so water current or debris will not affect the gate operation.

Structures shall have a stable outlet condition in the receiving ditch or channel. Additional outlet structures, devices or armoring may be required.

Structures that drain into a public roadway or drainage district ditch must have the written concurrence of the appropriate entity.

CONSIDERATIONS

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. 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.

Table 1

Minimum capacity for Full Flow Drop Spillways, Chute Spillways,

Box Inlet Drop Spillways and Toe Wall Drop Structures

Drainage Area (acre)	**Vertical Drop** (feet)	**Minimum Frequency** 1/	
		Structural Spillway Capacity (years)	**Total** 2/ **Capacity** (years)
250 or less	5 or less	5	10
500 or less	10 or less	10	25
All others		25	100

1/ Type II, 24-hour duration.

2/ Structure may carry total capacity.

Table 2

Minimum capacity for side inlet drainage structures

To be used where overflow can spread out and the structure, including pipe drop and hood inlets, carries only the flow delivered to it by the channel.

Drainage Area (acre)	**Vertical Drop** (feet)	**Principal Spillway Capacity** (cfs)	**Total Capacity Frequency** 1/2/ (years)
250 or less	5 or less	Design Drainage Curve 3/	5
450 or less	10 or less	Design Drainage Curve 3/	10
900 or less	10 or less	Design Drainage Curve 3/	25
All Others		Larger of : (a) Design Drainage Curve 3/ or (b) Bank Full Channel Capacity	50

1/ Capacity of principal spillway plus auxiliary spillway without overtopping structure. This requirement will be met without floodrouting on flat land where for all practical purposes storage is unlimited and top of settled fill meets requirements in this specification.

2/ Type II, 24-hour duration.

3/ Refer to NRCS standards, "Surface Drainage" (607) or "Main or Lateral" (608) for appropriate curve.

Table 3

Minimum design capacity of principal and auxiliary spillways
for embankment dams used for grade stabilization structures.

This standard does not apply to sites with overall dam height more than 35 feet.

Drainage Area (Acres)	**Effective Height of Dam** (Feet)	**Storage 1/** (Acre-Ft)	**Condition of Vegetated Spillway 2/**	**Principal Spillway Minimum Design Storm Frequency 3/** (Years)	**Auxiliary Spillway Minimum Design Storm Frequency 3/** (Years)
20 or less	20 or less	Less than 50	Good	1	10
			Fair or Poor	2	
	Greater than 20	Less than 50	All	2	25
21 to 100	20 or less	Less than 50	Good	1	25
			Fair	2	
			Poor	5	
	Greater Than 20	Less than 50	Good	2	50
			Fair	5	
			Poor	10	
101 to 200	20 or less	Less than 50	Good	1	25
			Fair	2	
			Poor	5	
	Greater Than 20	Less than 50	Good or Fair	5	50
			Poor	10	
201 to 400	20 or less	Less than 50	Good	2	25
			Fair or Poor	5	
ALL OTHERS (WITH OVERALL HEIGHT 35 FEET OR LESS)				10	50

1/ Total storage below crest of auxiliary spillway or top of dam if an auxiliary spillway is not provided.

2/ Good, Fair, and Poor describe condition from end of constructed auxiliary spillway to main channel or gully downstream from the dam.
Good - Stable, uniform grade from spillway exit to outlet channel, good sod.
Fair - Uniform grade with small drops, good sod; or uniform grade with small drops, fair vegetation, and shrubby banks.
Poor - Steep grades or raw gully banks, sparse vegetation.

3/ Type II, 24-hour duration.

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 the following items in the plans and specifications:

1. A plan view of the layout of the grade stabilization structure and appurtenant features.
2. Typical profiles and cross sections of the grade stabilization structure and appurtenant features as needed.
3. Structural drawings, as needed.
4. Seeding requirements, as needed.
5. Safety features.
6. Site specific construction requirements.
7. Drawings and general construction specifications shall be provided to the landowner or representative with sufficient copies for the contractor. Detailed construction specifications shall be prepared for the more complex sites. National guide specifications in NRCS handbooks shall be utilized in preparing these specifications. Missouri Construction Specification 378-A applies to dams associated with grade stabilization structures, 378-B applies to principal spillway conduits through embankment dams, 410-A applies to small full flow grade stabilization structures with fill height of 10 feet or less, and 410-B applies to grade stabilization structures in drainage systems.

OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for the operator. As a minimum, include the following items in the operation and maintenance plan:

1. Require periodic inspections of all structures, earthen embankments, spillways, and other significant appurtenances.
2. Require prompt repair or replacement of damaged components.
3. Require prompt removal of sediment when it reaches pre-determined storage elevations.
4. Require periodic removal of trees, brush, and invasive species.
5. Require periodic inspection of safety components and immediate repair if necessary.
6. Require maintenance of vegetative protection and immediate seeding of bare areas as needed.

REFERENCES

USDA Natural Resources Conservation Service. Engineering Technical Releases, TR-210-60, Earth Dams and Reservoirs. Washington, DC.

USDA Natural Resources Conservation Service. National Engineering Handbook, Part 628, Dams. Washington, DC.

USDA Natural Resources Conservation Service. National Engineering Handbook, Part 650, Engineering Field Handbook. Washington, DC.