NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

GRADE STABILIZATION STRUCTURE

(No.)

CODE 410

DEFINITION

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

PURPOSE

To stabilize grade, reduce gully erosion, and/or improve water quality.

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.

CRITERIA

General Criteria Applicable to All Purposes

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

Guidelines for selection of the type of structure are contained in National Engineering Handbook (NEH) Part 650 (Engineering Field Handbook) Chapter 6 Structures.

The landowner is responsible for acquiring land rights from adjoining landowners for any permanent or temporary storage created by the planned structure. The landowner is also responsible for obtaining permits to comply with applicable federal and state laws and regulations. See Table 5 for water storage and construction permit criteria.

The designer shall complete Form IA-ENG-40 for inventory dams. Submit the form to the State Conservation Engineer upon completion of construction. The thresholds that have been established for dam and reservoir sizes to be included in the inventory of NRCS-assisted dams may be found in Table 6.

Earth embankment 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.

Soils investigations shall be made of the structure site and borrow areas to determine the suitability of the foundation area and potential earthfill for construction and structure stability. Soils shall also be investigated in the permanent pool area to determine water holding potential when relevant to the purpose of, or impact to, the structure. Site investigations will be made in accordance with National Engineering Manual (NEM) Part 531 Geology.

The principal spillway shall be in alignment with the downstream channel. The downstream channel should be straight and cleared of all obstructions which cause turbulence, back-eddying, and meandering for a distance of approximately fifty (50) feet downstream from the spillway outlet.

Stability of grades below structures shall be determined by velocity calculations or by inspection. If the existing grade below the spillway is unstable, steps shall be taken to incorporate stabilizing features in the design of the spillway outlet and the discharge channel to avoid failure due to undercutting of the outlet. Generally, existing grades will be considered stable when:

1. The gully profile downstream has a uniform gradient.

2. Signs of scour on the channel bottom or sides are negligible or not apparent.
3. Grass and trees growing on the channel banks and bottom indicate that erosion has not been serious for a number of years.
4. Runoff is reduced substantially by detention structures and terraces.

Unobstructed flow to the inlets of principal and auxiliary spillways is essential to the hydraulic operation of these features. Closed conduit structures may require trash racks and regular debris removal. For open structures and auxiliary spillways, the design of the approach channel to the inlet shall be such that no channel restrictions or obstacles will interfere with the design flow. Refer to National Engineering Handbook (NEH), Part 628, Chapter 50, “Earth Spillway Design” for design considerations and processes involved with earth spillway design.

The exposed surfaces of the embankment, earth spillway, borrow area, and other areas disturbed during construction shall be seeded, sodded, or otherwise protected as necessary to prevent erosion according to guidelines in Critical Area Planting (342).

If the structure area is used by livestock, the structures, earthfill, vegetated spillways, and other areas shall be fenced as necessary to protect the structure. Near urban areas, fencing may be necessary to control access to prevent serious injury or death. It may also be necessary to exclude traffic to avoid damage to the vegetative cover.

All trees and shrubs must be cleared and grubbed the following minimum distances.

- For dry structures, the pool area must be cleared to a distance of 200 feet upstream from the principal spillway inlet, except that no clearing is necessary above the elevation of the top of the principal spillway inlet.
- For structures that retain water, the pool area must be cleared at least up to the elevation of the crest of the lowest principal spillway inlet. The minimum area cleared must extend the full length of the dam for a distance of 400 feet upstream from the principal spillway.
- For both types of structures, the area upstream of the emergency spillway must be cleared to the extent required for it to function properly.
- The minimum distance that must be cleared downstream of any earthfill or spillway is 30 feet.

Less clearing may be approved for a specific site if the structure incorporates fish and wildlife features and the sponsor or owner requests that the area not be cleared, or if the cost of clearing is disproportionate to the other costs of the structure and lack of clearing will not interfere with the functioning of the pool or structure.

New plantings shall not be made within these limitations. Grubbing will not be required below the normal waterline except on that portion of the area used as borrow or for placement of fill material.

Embankment Dams.

This section applies to all grade stabilization structures.

Low hazard dams with a product of storage times the effective height equal to or greater than 3,000, or with an effective height more than 35 feet; significant hazard dams; and high hazard dams shall meet or exceed the requirements specified in Technical Release (TR) 60. See NEM §520.21 for dam classification.

Low hazard dams that have a product of storage times the effective height less than 3,000 shall meet or exceed the requirements specified for Pond (378).

Closed Conduit Structures.

This section applies to detention and full flow closed conduit structures.

The minimum design capacity of the principal and auxiliary spillways shall be required to pass the peak flow expected from a 24-hour duration storm of frequency shown in Table 1, less any reduction attributed to retarding storage. In the case of full flow closed conduit structures, no reduction of peak flow due to retarding storage may be made.

If the pipe conduit diameter is 10 inches or greater its design discharge may be considered when calculating the peak outflow rate through the auxiliary spillway.

An auxiliary spillway must be provided for all dams except in the following cases: a detention structure where the combination of principal spillway discharge and retarding storage is adequate to pass the routed design hydrograph without overtopping the dam; or a full flow structure where the principal spillway capacity meets or exceeds the peak design flow criteria.

For structures designed without an auxiliary spillway, the minimum design of the closed conduit principal spillway shall include the following:

- A barrel with cross-sectional area of 3 square feet or more
- An inlet that will not clog
- An elbow designed to facilitate the passage of trash.
- A minimum of at least 2.0 feet of freeboard shall be provided.
- Detention structures: the principal spillway capacity and any associated temporary storage shall be designed for the 50-year frequency, 24-hour storm.
- Full flow structures: the principal spillway capacity shall be designed for the peak inflow from the 50-year frequency, 24-hour storm.
- All designs without an auxiliary spillway require approval from the State Conservation Engineer.

Detention structures must be designed with sediment storage capacity that is equal to the expected life of the structure or 35 years, whichever is greater, unless a provision is made for periodic cleanout. The drainage area above the structure must be protected against erosion to the extent that expected sedimentation will not shorten its planned effective life.

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 embankment can be designed to meet the requirements of Water and Sediment Control Basin (638) rather than the requirements of Pond (378). An auxiliary spillway is not required if the combination of storage and principal spillway discharge will handle the design storm without overtopping the structure**.** See Water and Sediment Control Basin (638) for other options for structures in deep gullies with small drainage areas.

A filter diaphragm is required for closed conduit structures when both of the following conditions exist:

1. The conduit has a diameter of 15 inches or more.

2. The maximum hydraulic head on the pipe is 6 feet or more. (Hydraulic head is measured from the highest water surface elevation of the auxiliary spillway routing to the 0.6d elevation at the outlet of the pipe.)

The filter diaphragm design shall be based on the design criteria of either Pond (378) or TR 60, whichever governs design of the structure. In cases where the design height of the filter diaphragm results in less than three feet of cover, the filter diaphragm shall extend to the elevation where three feet of cover is provided.

If the two conditions above don’t exist and the structure falls under the Pond (378) Standard, anti-seep collars may be used in lieu of a filter diaphragm. Follow design criteria for anti-seep collars found in the Pond (378) Standard.

Closed Conduit Structures

Table 1. Minimum Spillway Capacity

Drainage Area (Acres)	Minimum Pipe Diameter (Inches)	Effective Fill Height[1] (Feet)	Storage[1] (Acre-feet)	Minimum Design Frequency[2] (24-Hour Duration Storm) Principal Spillway (Year)	Auxiliary Spillway (Year)
0 – 20	4	0 – 20	Less than 50	- - -	10
0 – 20	4	20 – 35	Less than 50	2	25
20 – 80	6	0 – 20	Less than 50	5	25
20 – 80	6	20 – 35	Less than 50	5	50
80 – 250	10	0 – 20	Less than 50	10	25
80 – 250	10	20 – 35	Less than 50	10	50
All Others	15	0 – 35	- - -	25	50

[1] See definitions on page 9.

[2] If structure requires a permit from the IDNR more restrictive criteria may apply. See IDNR, Technical Bulletin 16, "Design Criteria and Guidelines for Iowa Dams."

Full-Flow Open Structures.

Full-flow open structures must safely pass the design storm through the structure by either a principal spillway designed for total capacity or by a combination of a principal spillway and auxiliary spillway. The hydraulic design of these structures shall not include credit for retarding storage. Examples include drop, chute, and box inlet spillways. These structures shall be designed according to the principles set forth in NEH Part 650, Chapter 6 – Structures, and other applicable NRCS design publications.

The minimum capacity of full flow open structures shall be that required to pass the peak flow expected from the 24-hour duration design storm with the frequency shown in Table 2. Structures must not create unstable conditions upstream or downstream. Provisions must be made to ensure stable reentry of bypassed storm flows.

A freeboard providing sidewalls a minimum of 6 inches higher than the water surface attained by the principal spillway design discharge shall be used. For chute structures lined with erosion resistant materials such as loose rock, gabions, grouted riprap, or concrete block, the top of the erosion resistant material shall be a minimum of 6 inches higher than the water surface attained by the principal spillway design discharge. When freeboard is included in the formula for a specific type of structure, such as may be found in the National Engineering Handbook (NEH), the formula shall govern minimum freeboard requirements. A minimum of 1.0 foot shall be provided between the top of the sidewalls and the top of the settled embankment. When the structure is a lined chute, a minimum of 1.0 foot shall be provided between the top of the erosion resistant material and the settled embankment.

Additional specific criteria apply to each type of full flow drop spillway as follows:

<u>Reinforced Concrete Chute Spillway:</u>
Use Section 14, National Engineering Handbook (NEH), for hydraulic design of reinforced concrete chute spillways and Saint Anthony Falls (SAF) outlets. The use of propped outlets is limited to spillways having a maximum discharge of 600 cfs or 50 cfs per foot of width, whichever governs.

<u>Straight Drop Spillway:</u>
Use Section 11, National Engineering Handbook (NEH), for hydraulic design of straight drop spillways. Design with freeboard as given by Equation 3.5 in Chapter 3. Maximum over fall

"F" will be 10 feet with a maximum weir depth "h" of 6 feet. Earth fill immediately adjacent to the weir opening will be scoured out by flows that approach design discharge unless adequate protection is provided. Since vegetation may not provide this protection, riprap is preferred. See Chapter 2, "Layout," of NEH 11 for proper design and placement of riprap.

Toe Wall Drop Spillway:
Use Engineering Field Handbook Chapter 6, "Structures" of NEH Part 650 for toe wall drop spillways with a vertical drop of up to and including 6 feet.

A toe wall drop spillway is used to provide a stable outlet for a grassed waterway and serves as a dividing point between a wet channel and a dry waterway. It may be used to provide an outlet for subsurface drains.

Toe wall drop spillways can be used if the vertical drop is 6 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 over fall. These limits may be exceeded if a site specific design is prepared.

The weir and headwalls of toe wall drop spillways may be fabricated from corrugated steel, aluminum sheets, fused glass, or fused plastic coated steel sheets. The toe wall and floor are composed of concrete. A vertical drop (F) of 6.0 feet and a notch depth (H) of 3.0 feet are the maximum for this type of structure. Dimensions, assembly, and installation must be in accordance with manufacturer's instructions.

Box-Inlet Drop Spillway:
Design guidance may be found in Agriculture Handbook No. 301, "Hydraulic Design of the Box-Inlet Drop Spillway". The maximum height "D" for the box is 10 feet.

Full Flow Open Structures

Table 2. Criteria For Determining Minimum Capacity Of Full Flow Open Structures

Maximum Drainage Area		Minimum Design Frequency (24-Hour Duration Storm)	
(Acres)	Vertical Drop (Feet)	Principal Spillway Capacity (Year)	Total Capacity (Year)
450	5 or less	5	10
900	10 or less	10	25
All Others		25	100

Box Inlets on Existing Road Culverts.

The minimum design weir capacity of a box inlet that is to be added to an existing road culvert shall either be the capacity required by the responsible road authority or the minimum capacity shown in Table 3, whichever is higher.

The dimensions of the box shall be sufficient to prevent submergence of the existing culvert headwall at minimum design capacity unless the headwall is raised and designed to act as an anti-vortex device. Scour protection shall be provided in accordance with NEH 11, Drop Spillways. If the culvert wings are flared out from the headwall so as to cause restriction of weir flow into the box, they shall be removed to the elevation of the inlet or the box dimensions increased to compensate for the restriction. The minimum unrestricted horizontal area of the top of the box inlet shall be 1.5 times the cross-sectional area of the culvert to which it is attached. The maximum design water surface elevation shall not be higher than 1 foot below the low point of the roadway.

Table 3. Design Capacity For Culvert Box-Inlets.

Culvert Capacity	Minimum Design Weir Capacity
$Q_c < Q_{50}$	$1.25Q_C$
$Q_{50} < Q_c < 1.50Q_{50}$	$1.25Q_{50}$ or Q_C (whichever is greater)
$> 1.50Q_{50}$	$1.50Q_{50}$

Island-Type Structures.

Island-type structures are a special case of the full-flow structure. For island-type structures out of bank flooding can be tolerated. The minimum capacity of the principal spillway of an island-type structure shall equal the capacity of the downstream channel. In no case shall it be less than the 2-year - 24-hour storm 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 shown in Table 2 without overtopping the headwall extensions of the principal spillway. Provision must be made for safe re-entry of bypassed flow as necessary.

Side-Inlet Drainage Structures.

Side-inlet drainage structure applications are intended where the hydrology is dominated by relatively flat landforms such as flood plains or the prairie pothole region and land management includes surface drainage. Drainage areas may not be well defined. Surface water may accumulate from uplands or from the backwater of a river system. These structures are used to lower surface water from field elevations or lateral channels into deeper open channels where gully erosion is the main resource concern.

Because inflow to the receiving channel is first a function of surface drainage, the minimum principal spillway capacity shall equal the design drainage curve runoff for all conditions (the volume of surface water drained per day which may also be expressed as inches per day for the land area being drained). The principal spillway capacity is not based on peak storm inflow from the drainage area. Design criteria for minimum capacity of open-weir or pipe structures used for this purpose are shown in Table 4.

Table 4. Design Criteria For Establishing Minimum Capacity Of Side-Inlet Drainage Structures[1]

Maximum Drainage Area	Frequency Of Minimum Design (24-Hour Duration Storm)			
(Acres)	Vertical Drop (Feet)	Receiving Channel Depth (Feet)	Principal Spillway Capacity	Total Capacity Year
450	0 - 5	0 - 10	*	*
450	5 - 10	10 - 20	*	10
900	0 - 10	0 - 20	*	25
All Others			*	50

[1] **Either open weir or pipe-drop structures may be used for side-inlet drainage structures.**

* Design Drainage Curve

CONSIDERATIONS

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.

Consider conservation and stabilization of archaeological and historic sites when designing this practice. This practice has the potential of positively and/or negatively affecting National Register listed or eligible (significant) cultural resources. Follow NRCS state policy for considering cultural resources during planning, construction, and maintenance.

Consideration should be given to the effect a structure will have on the aquatic habitat of a channel. If the channel supports fish, the effect of a structure on the passage of fish should be considered.

Crop damage upstream of a structure may occur due to detention. When possible, design the discharge from the structure to minimize crop damage. Always advise the landowner (or operator) when there is potential for crop damage.

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.

The following list of Construction Specifications is intended as a guide to selecting the appropriate specifications for each specific project. The list includes most but may not contain all of the specifications that are needed for a specific project:

IA-1	Site Preparation
IA-3	Structure Removal
IA-5	Pollution Control
IA-6	Seeding and Mulching for Protective Cover
IA-11	Removal of Water
IA-13	Sheet Piling
IA-21	Excavation
IA-23	Earthfill
IA-24	Drainfill
IA-26	Salvaging and Spreading Topsoil
IA-31	Concrete
IA-45	Plastic (PVC, PE) Pipe
IA-51	Corrugated Metal Pipe Conduits
IA-52	Steel Pipe Conduits
IA-61	Loose Rock Riprap
IA-62	Concrete Grout For Riprap
IA-64	Wire Mesh Gabions
IA-81	Metal Fabrication and Installation
IA-83	Timber Fabrication and Installation
IA-92	Fences
IA-95	Geotextile
IA-99	Cathodic Protection for Buried Metal Structures

OPERATION AND MAINTENANCE

An operation and maintenance plan shall be prepared for use by the owner or others responsible for operating and maintaining the system. The plan shall provide specific instructions for operating and maintaining the system to ensure that it functions properly. It shall also provide for periodic inspections and prompt repair or replacement of damaged components.

DEFINITIONS

Effective Fill Height: The difference in elevation in feet between the lowest open channel auxiliary spillway crest and the lowest point in the original cross section on the centerline of the dam. If there is no open channel auxiliary spillway, the top of the dam becomes the upper limit.

Fill Height: The difference in elevation in feet between the top of the dam and the lowest point in the original cross section on the centerline of the dam.

Overall Height: The difference in elevation in feet between the top of the dam and the lowest elevation at the downstream toe

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

Retarding Storage: The volume allotted to the temporary impoundment of floodwater. Its upper limit is the elevation of the crest of the auxiliary spillway. Its lower limit is the principal spillway crest. Aerated storage is deducted from the volume between the principal spillway crest and the auxiliary spillway crest.

Table 5. IDNR Storage and Construction Permit Criteria[1]

IDNR Approval Required for Dams in Rural Areas for the Following Instances	
Storage Permit (Iowa Administrative Code 567- 51.2)	a. 1) Permanent Storage > 18 Acre-Feet
Construction Permit (Iowa Administrative Code 567- 71.3)	a. 1) Total Storage at Top of Dam: ≥ 50 Acre-Feet with Auxiliary Spillway, or ≥ 25 Acre-Feet with No Auxiliary Spillway And 2) Overall Height ≥ 5 Feet ***OR***
	b. 1) Permanent Storage > 18 Acre-Feet And 2) Overall Height ≥ 5 Feet ***OR***
	c. 1) Drainage Area > 10 square miles ***OR***
	d. 1) Within 1 mile of an incorporated municipality And 2) Overall Height ≥ 10 Feet And 3) Total Storage at Top of Dam ≥ 10 Acre-Feet And 4) Discharge from dam flows through incorporated area

[1] Any structure that does not meet the criteria for 'Exempt' status, or does not fall under Regional Permit 33, requires an individual permit under Section 404 of the Federal Water Pollution Control Act which is administered by the U.S. Army Corps of Engineers. For both Section 404 and Regional Permit 33 use Joint Application Form 36.

Table 6. National Inventory of Dams[*] Criteria

1)		
	a.	Overall height ≥ 6 Feet, and
	b.	Storage capacity ≥ 50 Acre-Feet
OR		
2)		
	a.	Overall height ≥ 25 Feet, and
	b.	Storage capacity ≥ 15 Acre-Feet

[*] The National Inventory of Dams is in accordance with §520.21(f), National Engineering Manual (NEM), and is part of the NRCS program for dam safety.