Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

DIKE

CODE 356

(ft)

DEFINITION

A barrier constructed of earth or manufactured materials.

PURPOSE

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

- To protect people and property from floods
- To control water level in connection with crop production; fish and wildlife management; or wetland maintenance, improvement, restoration, or construction

CONDITIONS WHERE PRACTICE APPLIES

All sites that are subject to damage by flooding or inundation and where it is desired to reduce the hazard to people and to reduce damage to land and property.

Sites where the control of water level is desired.

The dike standard does not apply to sites where NRCS Conservation Practice Standards Pond (378), Water and Sediment Control Basin (638), Diversion (362), or Terrace (600) are appropriate. Dikes used to reduce flooding are normally constructed parallel, and if applicable, adjacent to a stream, river, wetland, or water body and are not constructed across the stream, river, or water body. Dikes used to control water levels usually have small interior drainage areas in relation to the surface area of the regulated water level.

CRITERIA

General Criteria Applicable to all Purposes

Classification

The dike classification is determined by the hazard to life, the design water height, and the value of the protected land, crops, and property.

Classification must consider land use changes likely to occur over the life of the dike. Class I and II dikes require the approval of the State Conservation Engineer.

Dikes are classified as Class I when located on sites where failure may cause loss of life or serious damage to homes, primary highways, industrial buildings, commercial buildings, major railroads or important public utilities.

All dikes with a design water height of more than 12 feet above normal ground surface, exclusive of crossings of sloughs, old channels, or low areas, shall be classified as Class I.

Dikes are classified as Class II when located on sites where failure may cause damage to isolated homes, secondary highways, minor railroads, relatively important public utilities, high value land, or high value crops.

Dikes are classified as Class III when located on sites where damage likely to occur from failure will be minimal.

Constructed Elevation
The constructed elevation of a dike whose purpose is to prevent flooding shall be the sum of the following:

- The water elevation attained by a flood of the design frequency shown in Table 1 with the critical duration and timing. This is the design high water.
- The larger of the minimum freeboard in Table 1 or the wave height caused by wind. The constructed elevation of a dike whose purpose is to control water level shall be the sum of the following:
    - The water elevation at the highest water level control.
    - The rise in water height above the highest water level control caused by a flood of the design frequency shown in Table 1. This is the design high water.
    - The larger of the minimum freeboard shown in Table 1 or the wave height caused by wind of the design frequency shown in Table 1.
    - The allowance for settlement.

The dike shall not back surface water onto an adjoining property unless authorized through a written easement, permit or equivalent legal document.

Settlement
Settlement shall be based on an analysis of the fill material, foundation material and condition, and compaction methods.

In lieu of an analysis, the allowance for settlement shall be as follows:

- For dikes constructed of compacted earth fill material the allowance for settlement shall be a minimum of 5 percent of the dike height.
- For Class II or Class III dikes constructed of fill material that is hauled from off-site, dumped, and shaped, the allowance for settlement shall be a minimum of 15 percent of the dike height. For fill material that is excavated adjacent to the dike and dropped from the excavator, the allowance for settlement shall be a minimum of 20 percent of the dike height. The allowance for settlement of dumped and shaped or dropped organic soil fill material shall be a minimum of 40 percent of the dike height. Organic soils are permitted only for Class III dikes 6 feet or less in height. Higher dike heights result in excessive settlement and decomposition.

For the purpose of this standard, organic soils are described by one of the following:

- Soil layers that are not saturated with water for more than a few days at a time are organic if they have 20 percent or more organic carbon.
- Layers that are saturated for longer periods, or were saturated before being drained, are organic if:
    - They have 12 percent or more of organic carbon and no clay, or
    - 18 percent or more organic carbon and 60 percent or more clay, or
    - A proportional amount of organic carbon, between 12 and 18 percent, if the clay content is between 0 and 60 percent.
- All soils described in the local soil survey as an organic soil.

Top Width and Side Slopes
The minimum top widths and side slopes for earth embankments shall be as shown in Table 1.

All dikes must be accessible for maintenance activities. Typically, this may be along the top of the dike or along the berm. Access roads shall provide adequate width for the maintenance equipment and inspection vehicles. The minimum width for vehicular traffic should be 12 feet. Provide wider areas for passing and turning around at regular intervals. Access roads may need to be controlled to prevent vandalism, accidents, and damage.

Berms

The need for a constructed berm on an embankment will be based on the results of an embankment and foundation stability analysis. If a stability analysis is not performed, all earth dikes shall have berms either constructed or occurring naturally on both sides meeting the following criteria:

- Constructed berms shall be at a constant elevation and sloped away from the dike.
- Where dikes cross channels, ditches, borrow areas, streams, sloughs, swales, gullies, etc., they shall have a berm constructed on each side. The top elevation of these berms shall be at least 1 foot above the average ground surface on each side of the channel, ditch, borrow area, stream, slough, swales, gully, etc., and sloped away from the dike.
- The minimum top width of natural or constructed berms shall be as shown in Table 1.
- The minimum side slope ratio of constructed berms shall be 2:1 (Horizontal:Vertical).

Dike Materials

Manufactured materials are erosion resistant materials such as concrete, PVC, steel, or other material that provides the required structural strength and durability for the dike. Dikes constructed of manufactured materials shall have a structural analysis completed for the various loads the dike will be subjected to during its life. These include hydrostatic, ice, uplift, earth, and equipment. The dike shall be analyzed for stability using acceptable safety factors for each loading condition.

Earth dike materials shall be obtained from required excavations and designated borrow areas. The selection, blending, routing, and disposition of materials in the various fills shall be subject to approval by the engineer or designer. Fill materials shall contain no frozen soil, sod, brush, roots, or other perishable materials. Rock particles larger than the maximum size specified for each type of fill shall be removed prior to placement and compaction of the fill. The types of materials used in the various fills shall be as listed and described in the specifications and drawings.

Embankment and Foundation Seepage

Embankment and foundation drainage and seepage control shall be designed on the basis of site investigation, laboratory data, seepage analysis, and stability analysis. The resulting design shall minimize seepage, prevent piping or undermining, and provide a stable embankment and foundation.

An analysis is required on all Class I dikes that have a height of 6 feet or greater and Class II dikes that have a height of 8 feet or greater.

In the absence of more detailed data and analysis, the following criteria for a foundation cutoff apply for Class I dikes less than 6 feet in height, Class II dikes less than 8 feet in height and Class III dikes:

- Minimum of H feet deep for H<3 feet
- Minimum of 3 feet deep for H³3 feet
- Minimum of 4 feet bottom width
- 1:1 or flatter side slopes

For dikes where the design water depth is more than 6 feet, a stream, channel, ditch, borrow area, slough, swale, gully, etc., shall be far enough away from the dike so that the extension of a line drawn from the design high water elevation on one side of the dike to the dike toe on the opposite side shall not intersect any stream, channel, etc. (See Figure 1). This line criterion applies to both sides of the dike. This criterion will minimize the hazard to the dike caused by piping through the foundation.

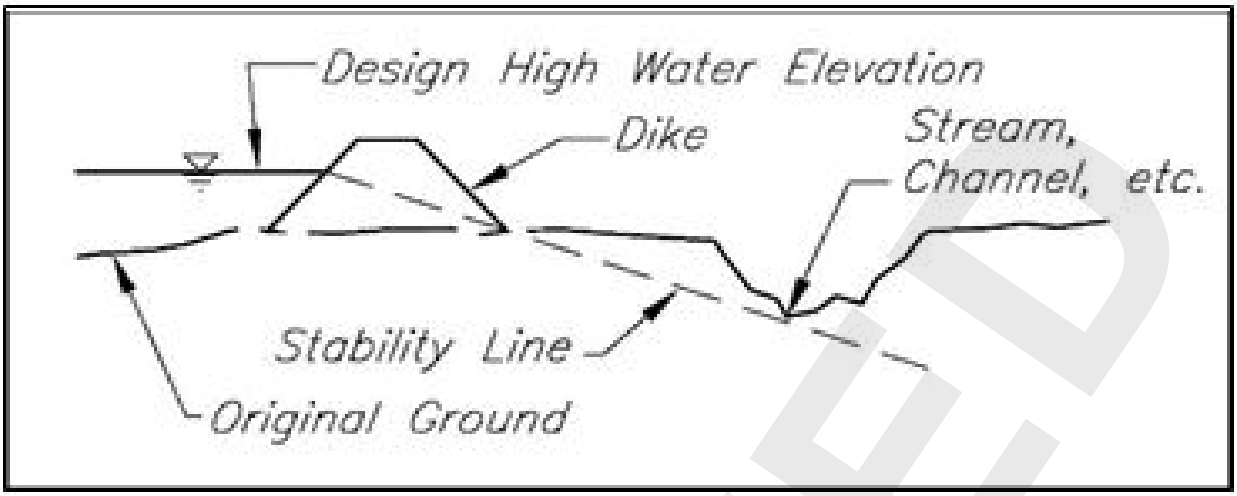

Figure 1. Dike location relative to a channel or other depression feature.

Interior Drainage
Dikes to prevent flooding shall be provided with interior drainage systems for the area being protected. The interior drainage system shall prevent flood damage to the interior area from a flood of the design frequency in Table 1 for both the 1-day and the 10-day storm duration for Class I and II dikes, and the 1-day storm duration for Class III dikes. The interior drainage system may include storage areas, gravity outlets, and pumping plants as needed to provide the required level of flood protection.

Pipes
Pipes installed through a Class I dike below the design high water with a dike height greater than 12 feet shall meet the requirements for principal spillways as found in Technical Release 60 (TR-60), except for the minimum size requirements.

Pipes through Class III dikes less than 5 feet high used for water level control shall meet the requirements of Structure for Water Control (587).

Pipes through all other dikes shall meet the requirements for a principal spillways in Pond (378).

Dikes shall be protected from scour at pipe inlet and outlet locations by appropriate measures. A pump discharge pipe through a dike shall be installed above design high water, if feasible. Pump discharge pipes shall be equipped with a flexible connection or similar coupling to prevent vibration of the pumping plant being transmitted to the discharge pipe.

Slope Protection
Slopes of earthen dikes shall be protected from sheet, rill, and gully erosion; erosion from flowing floodwaters; and wave action created by wind and/or boat traffic.

Erosion protection measures such as non-woody vegetation, berms, rock riprap, sand-gravel, or soil cement shall be utilized as needed.

Adverse Impacts
Environmental impacts from the proposed dike shall be evaluated. Any increases in flood stage caused by dike induced flow restrictions shall be evaluated for adverse impacts to unprotected areas. Adverse impacts shall be minimized.

Additional Criteria for Dikes Constructed for Wetland Restoration, Creation, or Enhancement

See Table 1 for design criteria for wetland embankments. Where H exceeds 3.0 feet, design wetland embankments to meet criteria found in Pond (378) or other appropriate practice standard. Wetland embankments shall also meet the criteria found in Wetland Restoration (657).

A wave protection berm not less than 10 feet wide is recommended for all wetland dikes. The berm shall be provided at or above normal pool elevation to dampen out wave action. A wave protection berm shall be required when the normal water depth at the dike is greater than 4 feet and the portion of the pool area deeper than 4 feet is greater than 5 acres.

A berm with a minimum 10 foot radius shall be provided around a 24 inch diameter or larger water control structure.

If muskrats or other burrowing animals are a concern to the dike integrity, install one of the following measures:

- 10 foot berm 0.5 foot above the crest elevation, or
- sloping berm at 10:1 or flatter with a minimum width of 10 feet above crest elevation.

Table 1 - Minimum Design Criteria for Dikes

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Classification	Material [1/]	Height (H) in Feet [2/]	Minimum Storm Design Frequency in Years	Minimum Freeboard in Feet	Minimum Top Width in Feet	Minimum Side Slope Ratio [3/] (H:V)	Berm Width in Feet
Class I	Earth	0 to 6	100	H/3	10	2:1	12
		>6 to 12	100	2	10	Note [4/]	Note [4/]
		>12 to 25	100	3	12	Note [4/]	Note [4/]
		>25	100	3	14	Note [4/]	Note [4/]
	Manufactured	0 to 8	100	H/4	N/A	N/A	Note [4/]
		>8 to 12	100	2	N/A	N/A	Note [4/]
		>12	100	3	N/A	N/A	Note [4/]
Class II	Earth	0 to 6	25	H/3	6	2 ½:1 [5/]	12
		>6 to 12	25	2	8	2 ½:1	15
	Manufactured	0 to 8	25	H/4	N/A	N/A	Note [4/]
		>8 to 12	25	2	N/A	N/A	Note [4/]
Class III	Mineral Soils	0 to 3	10	H/3	6	2:1	8
		>3 to 6	10	1	6	2:1	8
		>6 to 12	25	2	8	2:1	8
	Organic Soils [6/]	0 to 2	10	H/2	6	2:1	10
		>2 to 4	10	1	6	2:1	10
		>4 to 6	10	2	8	2:1	15
Wetland Embankment	Mineral Soils	0 to 3	10	H/3	10 [7/]	10:1 [8/]	10

[1/] Earth includes rock. Manufactured materials are erosion resistant materials such as concrete, PVC and steel that provides the structural strength for the dike.

[2/] Height is the difference between normal ground elevation at the dike centerline and the design high water elevation. When determining normal ground elevation, exclude crossings of channels, sloughs, small low areas, small ridges, swales, or gullies.

[3/] Minimum side slope ratios are for compacted earth fill. Dumped earth fill without compaction will be flatter.

[4/] Side slope ratios and berm widths shall be determined by a stability analysis.

[5/] Side slopes of 3:1 on watersides and 2:1 on landside may be used instead at 2 ½:1 for both sides.

[6/] Organic soils are permitted only for Class III dikes 6 feet or less in height. Higher dike heights result in excessive settlement and decomposition.

[7/] Increase the top width when the dike is likely to be overtopped by flood flows in Riverine floodplains.

[8/] Use side slopes that will enable the dike to blend into the landscape. Steeper side slopes may be used if they fit site conditions.

CONSIDERATIONS

General Considerations

For Class I dikes, consider the flood of record when establishing the top of dike elevation.

Consider fluvial geomorphologic concepts contained in NEH, Part 653, Stream Corridor Restoration Principles, Processes, and Practices when placing a dike near a stream.

Give special consideration to wider berms, additional setbacks, or protecting the berm side slope when adjacent to actively eroding or moving streams to protect the dike for its design life.

Dike construction may constitute an encroachment on the flood plain requiring permits.

PLANS AND SPECIFICATIONS

Plans and specifications shall be prepared in accordance with the criteria of 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-9 Subsurface Drain Investigation, Removal, and Repair
- IA-11 Removal of Water
- IA-21 Excavation
- IA-23 Earthfill
- IA-26 Topsoiling
- IA-27 Diversion
- IA-45 Plastic (PVC, PE) Pipe
- IA-46 Tile Drains for Land Drainage
- IA-51 Corrugated Metal Pipe Conduits
- IA-52 Steel Pipe Conduits
- IA-61 Loose Rock Riprap
- IA-81 Metal Fabrication and Installation
- IA-83 Timber Fabrication and Installation

OPERATION AND MAINTENANCE

Operation and maintenance requirements for all dikes will be provided to the landowners. Specified actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance).

For Class I dikes with a height greater than 12 feet, an emergency action plan meeting the requirements of the National Operation and Maintenance Manual, Section 500.70, shall be completed prior to construction of the dike.

For Class I and Class II dikes, a detailed written Operation and Maintenance Plan in accordance withthe National Operation and Maintenance Manual, Section 500.40 through 500.42, shall be completed and provided to the owner.

At the minimum, the following activities shall be addressed in the plan:

- Inspection schedule of dikes and appurtenances for damage assessment,
- Inspect for damage caused by burrowing rodents and repair damage as needed, and

- Management needed to maintain vegetation, including control of unwanted vegetation in and around the wetland area.

REFERENCES

USDA-NRCS, Technical Release 60 (TR-60), Earth Dams and Reservoirs

USDA-NRCS, National Engineering Handbook (NEH), Part 653

USDA-NRCS, National Operation and Maintenance Manual

USDA-NRCS, National Engineering Handbook (NEH), Part 650, Engineering Field Handbook (EFH), Chapter 13