# 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 Virginia Conservation Practice Standards *Pond (Code 378)*, *Water and Sediment Control Basin (Code 638)*, *Diversion (Code 362)*, or *Terrace (Code 600)* are appropriate.

Dikes used to reduce flooding are normally constructed adjacent and/or parallel 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**

**Regulatory Requirements**

Dikes shall meet the requirements of all federal, state, and local laws or regulations.

**Location**

When locating the site for the dike, evaluate the foundation soils, property lines, setbacks from property lines, exposure to open water, distance to streambanks, availability of outlets by gravity or pumping, buried, utilities, cultural resources, and natural resources such as wetlands, natural areas, and fish and wildlife habitat.

If dike construction will adversely affect such values, the appropriate regulatory agencies shall be consulted about the project.

**Site Preparation**
Preparation of sites for dike construction shall be done in a manner which destroys as little vegetation outside the areas to be occupied by dikes and borrow pits as feasible. Special efforts shall be made to save trees of significant value which are not in the area to be occupied by the dike.

Construction operations shall be conducted to minimize air and water pollution within legal limits. Bare areas shall be revegetated as soon as practical after earthwork is complete. A minimum area should be stripped of vegetation at any one time to provide an adequate work site.

Site preparation debris disposal shall cause minimum pollution to the environment.

NRCS environmental policy must be observed. All federal, state, and local permits must be obtained by the owner before NRCS construction assistance is provided.

**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.

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 is 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 or high tide 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 or boat traffic.
- The allowance for settlement.

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.

If the dike will be subject to stages from more than one stream or source, the criteria indicated shall be met for the combination that causes the highest stage.

If the dike will be subject to tidal influence as well as streamflow, the peak shall be assumed to occur in conjunction with the mean high tide to determine the design high water depth.

**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 shall be a minimum of 5% of the dike height.
- For Class II or Class III dikes, constructed of fill material that is hauled from off-site, dumped, and shaped (referred to as “dumped and shaped”), the allowance for settlement shall be a minimum of 15% of the dike height. For fill material that is excavated adjacent to the dike and dropped from the excavator (referred to as “dropped”), the allowance for settlement shall be a minimum of 20% of the dike height. The allowance for settlement of dumped and shaped or dropped organic soil fill material shall be a minimum of 40% 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 as follows:

- 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; or
- 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; or
- 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.

**Ditches and Borrow Pits**
Landside ditches or borrow pits shall be located so the hazard of failure is not increased. Ditches for borrow pits when excavated on the water side of dikes shall be wide and shallow. Plugs, at least 15 feet in width, shall be left in the ditch at intervals not greater than 400 feet to form a series of unconnected basins.

**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 six (6) feet or greater and Class II dikes that have a height of eight (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 foot bottom width.
- 1:1 or flatter side slopes.

The cutoff shall have a bottom width and side slope adequate to accommodate the equipment to be used for excavation, backfill, and compaction operations. It shall be backfilled with suitable material placed and compacted as required for the earth embankment. If pervious foundations are too deep to be penetrated by a foundation cutoff, a drainage system adequate to ensure stability of the dike shall be used.

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.

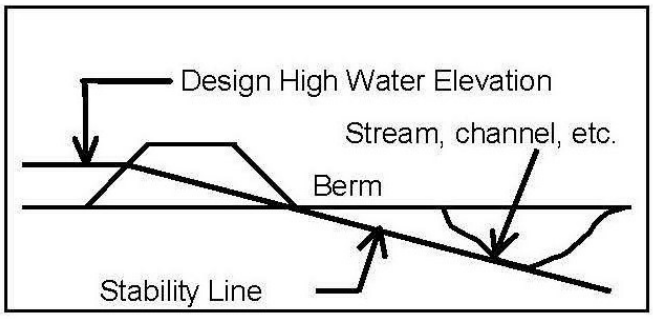


*Figure 1. Relative location of dike to stream channel, ditch, borrow area, slough, gully, etc.*

Provisions must be made for adequate drainage for the area to be protected by the dike.

Drains shall be used when necessary to ensure safety of dikes and shall be located on the land side, have a graded sand gravel filter, and be designed and installed in accordance with NRCS National Engineering Handbook (NEH) Part 633, Chapter 26.

Subsurface drains shall not be installed or permitted to remain without protection, closer to the landside toe of a dike than a distance three times the design water height for the dike.

**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. 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 NRCS TECHNICAL RELEASE 60 – Earth Dams and Reservoirs, except for the minimum size requirements.

Pipes through all other dikes shall meet the requirements for a principal spillway in the Virginia NRCS Conservation Practice Standard *Pond (Code 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.

## CONSIDERATIONS

**General Considerations**

**Flood of record**
For Class I dikes, the flood of record should be considered when establishing the top of dike elevation.

**Berms**
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.

**Adverse impacts**
Adverse environmental impacts from the proposed dike will be evaluated. Any increases in flood stage caused by dike-induced flow restrictions will be evaluated for adverse impacts to unprotected areas. Adverse impacts should be minimized.

Fluvial geomorphologic concepts contained in National Engineering Handbook (NEH) Part 653, Stream Corridor Restoration Principles, Processes and Practices should be considered when placing a dike near a stream.

Consider the effects of the dike upon component of the water budget, especially on volumes and rates of runoff, infiltration, evaporation, and transpiration.

Potential for changes in rates of plant growth and transpiration because of changes in the Volume of soil water should be evaluated.

Effects on downstream flows or aquifers that would affect other water uses or users should be assessed.

Consideration should be given to the effects on the rate or volume of downstream flow in order to prohibit undesirable environmental, social, or economic effects.

Consider the effects of the dike on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.

Effects on the movement of dissolved substances to groundwater should be considered.

Short-term, construction and maintenance related effects on the quality of water resources should be assessed.

Consider the potential for earth moving to uncover or redistribute toxic materials such as saline soils which could produce undesirable effects on water or vegetation.

Consideration should be given to the effects on temperature of water resources to prevent undesired effects on aquatic and wildlife communities.

Effects on wetlands or water-related wildlife habitats should be evaluated.

Effects on the visual quality of water resources should be assessed.

Consider the effects of inundation of the dike when selecting vegetative or non-vegetative covers.

## 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.

Record all required information in an engineer field book, on a plan sheet or design computation sheet, or in another appropriate location.

DESIGN DATA

- Completed Environmental Evaluation (Form VA-EE-1) and subsequent requirements.
- Soils investigation.
- Survey and plot data:  profile, cross-sections, topography, as needed.
- Design computations, including purpose of practice and references used.
- Plan view of site with existing and planned features, including dimensions, distances, etc.
- Standard Cover Sheet (VA-SO-100A).
- Materials and quantities needed.  Identify borrow material and/or spoil area, as needed.
- Vegetation and/or ground cover requirements.
- Identification of needed Erosion & Sediment Control measures.
- Supplemental practices required.
- Virginia Conservation Practice Specifications (700 Series).
- Operation and Maintenance Plan.

CHECK DATA

- As-built survey.
- As-built plans including dimensions, types and quantities of materials installed, and variations from design.  Include justification for variations.
- Locations of appurtenant practices.

- Adequacy of vegetation and/or ground cover.
- Complete as-built section of Cover Sheet.

## OPERATION AND MAINTENANCE

Operation and maintenance requirements for all dikes will be provided to the landowners. For Class I dikes with a height greater than 12 feet, an emergency action plan meeting the requirements of 500.70 of the National Operation and Maintenance Manual 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 with 500.40 through 500.42 of the National Operation and Maintenance Manual shall be completed and provided to the owner.

All dikes must be adequately maintained to the required shape and height. The maintenance of dikes must include periodic removal of vegetation that may become established on the embankment. Provisions for maintenance access must be provided.

Burrowing animals shall be removed and the damage repaired.

## REFERENCES


1. USDA-Natural Resources Conservation Service. National Engineering Handbook, Parts 5, 630, 633, and 650.
2. USDA-Natural Resources Conservation Service., TR-210-60 - Earth Dams and Reservoirs (Revised July 2005) (7/2005), TR-210-69 - Riprap for Slope Protection Against Wave Action (2/1983)
3. USDA-Natural Resources Conservation Service. General Manual Title 330. Available at http://policy.nrcs.usda.gov
4. USDA-Natural Resources Conservation Service. General Manual 190, Part 410. Available at http://policy.nrcs.usda.gov
5. USDA-Natural Resources Conservation Service. Electronic Field Office Technical Guide (eFOTG), Section IV [Online]. Available at http://www.nrcs.usda.gov/technical/eFOTG
6. USDA-Natural Resources Conservation Service. Virginia 700 Series Construction Specifications. [On-line]. Available at http://www.nrcs.usda.gov/technical/eFOTG

**Table 1 – Minimum Design Criteria for Dikes**

| 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 | 2:1 | 12 |
| | | >6 to 12 | 25 | 2 | 8 | 2:1 | 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 | 4 | 2:1 | 8 |
| | | >3 to 6 | 10 | 1 | 6 | 2:1 | 8 |
| | | >6 to 12 | 25 | 2 | 8 | 2:1 | 8 |
| | Organic Soils [5/] | 0 to 2 | 10 | H/2 | 4 | 2:1 | 10 |
| | | >2 to 4 | 10 | 1 | 6 | 2:1 | 10 |
| | | >4 to 6 | 10 | 2 | 8 | 2:1 | 15 |

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