## Natural Resources Conservation Service

## CONSERVATION PRACTICE STANDARD

# DIKE AND LEVEE

## CODE 356

## (ft)

### DEFINITION

A barrier used to retain water on the landscape using a wetland dike; or, a barrier used to exclude water from the landscape and protect property and infrastructure from flooding using a flood control levee.

### PURPOSE

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

- Manage water retained on the landscape using a dike
- Reduce flood risk by excluding water from a landscape using a levee

### CONDITIONS WHERE PRACTICE APPLIES

This practice applies where flooding puts land and property at risk of damage; or, where management of water levels is needed for activities, such as wetlands management, fish and wildlife habitat management, irrigation or drainage water management, and crop production.

Dikes and levees are separate and distinguishable. For purposes of this standard, the terms are not interchangeable. Failure of a dike will result in no damage to adjacent property or infrastructure. Levees protect adjacent property and infrastructure and have the potential to cause significant damage upon failure. In addition, levees will be subject to future Federal reporting requirements. Both levees and dikes may have State, Tribal, or local reporting requirements.

This practice does not apply to sites where the following NRCS Conservation Practice Standards (CPSs) are more appropriate:

- Dam (Code 402)
- Diversion (Code 362)
- Dam, Diversion (Code 348)
- Grade Stabilization Structure (Code 410)
- Pond (Code 378)
- Terrace (Code 600)
- Water and Sediment Control Basin (Code 638)

### CRITERIA

**General Criteria Applicable to all Purposes**

**Regulatory requirements**

Dikes and levees must meet the requirements of all Federal, State, Tribal, and local laws or regulations. Notify landowner and contractor of their responsibility to locate all buried utilities in the project area,

including drainage tile and other structural measures. The landowner is also required to obtain all necessary permits for project installation prior to construction.

**Classification and design criteria**

The factors determining dike and levee classification include purpose; potential hazard to life; design high water height; value of the protected land, crops, and property; and land use changes likely to occur over the life of the dike or levee. Hazard potential for levees parallels those for dams in the NRCS National Engineering Manual (NEM) (Title 210), Subpart C, Section 520.21, "Definition and Classes," but is not the same. Classes of dikes and levees are specified below. Table 1 contains their minimum design criteria.

Class I

- All levees located on sites where a potential failure may cause loss of life or serious damage to homes, primary highways, industrial buildings, commercial buildings, major railroads, or important public utilities.
- All levees regardless of potential damage upon failure with a design high-water height of more than 12 feet above normal ground surface at the levee, exclusive of crossings of sloughs, old channels, or low areas.
- All dikes with a design high-water height of more than 12 feet above normal ground surface at dike centerline, exclusive of crossings of sloughs, old channels, or low areas.

Class II

- All levees located on sites where potential failure may cause damage to isolated homes, secondary highways, minor railroads, relatively important public facilities, high value land, or high value crops.
- All levees regardless of potential damage upon failure with a design high-water height of greater than 8 feet and up to 12 feet above normal ground surface at the levee centerline exclusive of crossings of sloughs, old channels, or low areas.
- All dikes with a design high-water height of greater than 8 feet and up to 12 feet above normal ground surface at the levee or dike centerline exclusive of crossings of sloughs, old channels, or low areas.

Class III

- All levees located on sites where failure is likely to cause minimal damage.
- All levees, regardless of potential damage upon failure with a design high-water height of greater than 6 feet and up to 8 feet above normal ground surface at the levee exclusive of crossings of sloughs, old channels, or low areas.
- All dikes with a design high-water height of greater than 6 feet and up to 8 feet above normal ground surface at the dike centerline exclusive of crossings of sloughs, old channels, or low areas.

Class IV

- All dikes located on sites where damage from overtopping is insignificant, used solely for managing water levels for purposes such as irrigation or management of wetland and wildlife areas; and with a design high-water height of 6 feet or less above normal ground surface at the dike centerline exclusive of crossings of sloughs, old channels, or low areas.

**Table 1 - Minimum Design Criteria for Dikes and Levees**

| Classification | Material[1/] | Design High-Water 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) | Wave and Stability Berm Width in feet [4/] |
|---|---|---|---|---|---|---|---|
| Class I | Mineral Soils | 0–6 | 100 | H/3 | 10 | 3:1 | 12 |
| | | > 6–12 | 100 | 2 | 10 | Note[4/] | Note[4/] |
| | | >12–25 | 100 | 3 | 12 | Note[4/] | Note[4/] |
| | | > 25 | 100 | 3 | 14 | Note[4/] | Note[4/] |
| | Manufactured | 0–8 | 100 | H/4 | N/A | N/A | Note[4/] |
| | | > 8–12 | 100 | 2 | N/A | N/A | Note[4/] |
| | | > 12 | 100 | 3 | N/A | N/A | Note[4/] |
| Class II | Mineral Soils | 0–6 | 25 | H/3 | 6 | 3:1 | 12 |
| | | >6–12 | 25 | 2 | 8 | 3:1 | 15 |
| | Manufactured | 0–8 | 25 | H/4 | N/A | N/A | Note[4/] |
| | | > 8–12 | 25 | 2 | N/A | N/A | Note[4/] |
| Class III | Mineral Soils | 0–3 | 10 | H/3 | 4 | 3:1 | 8 |
| | | > 3–6 | 10 | 1 | 6 | 3:1 | 8 |
| | | > 6–12 | 25 | 2 | 8 | 3:1 | 8 |
| | Organic Soils[5/] | 0–2 | 10 | H/2 | 4 | 3:1 | 10 |
| | | > 2–4 | 10 | 1 | 6 | 3:1 | 10 |
| | | > 4–6 | 10 | 2 | 8 | 3:1 | 15 |
| | Manufactured | > 6–8 | 10 | N/A | N/A | N/A | Note[4/] |
| Class IV | Mineral Soils or Organic Soils[5/] | < 6 | 10[6/] | 0.5[7/] | 4 | 3:1 | N/A |
| | Manufactured | < 6 | 10[6/] | 0.5[7] | N/A | N/A | N/A |

[1] Earth includes rock. Manufactured materials are erosion-resistant materials, such as concrete, PVC, steel, or other materials that provide the structural strength for the dike or levee.

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

[3] Minimum side-slope ratios are for compacted earth fill.

[4] The need for wave and stability berms is determined through embankment and stability analysis. If no analysis is performed, the values for wave and stability berm widths are defaults. Where values are not included in the table, there is no default and side-slope ratios and wave and stability berm widths are determined by the stability analysis.

[5] Organic soils are permitted only for Class III or Class IV dikes with a design high-water height of 6 feet or less.

[6] Applied only to the storm from the local drainage area and not to the watershed that is contributing to flooding of the dike.

[7] For a dike with an auxiliary spillway, this refers to the difference between the auxiliary spillway elevation and the design top of the dike elevation. For a dike without an auxiliary spillway, this refers to the difference between the highest water level control elevation and the top of the dike elevation.

**Location**

- Evaluate property lines, setbacks from property lines, exposure to open water, distance to streambanks, availability of gravity and pumped outlets, drainage tile, buried utilities, cultural resources, other structural measures, and natural resources such as wetlands, natural areas, and fish and wildlife.
- Identify and minimize the potential adverse impacts from installation of the dike or the levee. Include the environmental impacts of the physical presence of the dike or the levee and the potential for induced flooding in adjacent areas.
- Construct levees adjacent or parallel to streams, rivers, or other water bodies; and, not across streams, rivers, or other water bodies.

**Geologic investigation**

For all dikes or levees, perform a geologic subsurface investigation in sufficient detail and analysis to support the design and characterize borrow material. Describe the soil material, subgrade conditions, bearing capacity, depth to bedrock, and any geologic conditions or hazards to address in the design, construction, or operation of the dike or levee. Refer to 210-NEM, Part 531, “Geology.”

**Foundation preparation**

For all Class I through Class III levees or dikes, clear the foundation area of all trees, stumps, roots, brush, organic matter, and other debris. Remove unstable soil prior to the placement of levee or dike material.

For all levees or dikes, stockpile topsoil for placement of the finished dike or levee or borrow area if needed to help reestablish vegetative cover.

For a Class IV dike, remove the topsoil to a minimum depth of 0.3 feet under the entire footprint of the dike.

**Constructed elevation**

Flood-control levee

The constructed top elevation of a flood-control levee is the sum of—

- The design high-water height, defined as the highest water surface elevation attained by a flood or high tide of the design frequency shown in table 1 with the critical duration and timing,
- 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 or boat traffic, and
- The allowance for settlement.

Water-level management dike

The constructed top elevation of a water-level management dike is the sum of—

- The water elevation at the highest water-level control,
- The rise in water surface elevation above the highest water level caused by a flood of the design frequency shown in table 1 (this is the design high-water height),
- 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, and
- The allowance for settlement.

**Settlement**
Base the allowance for settlement on an analysis of the fill material, foundation material and condition, and compaction methods.

In lieu of an analysis, use the following minimum allowance for settlement:

- For a dike or levee constructed of compacted mineral soil (earth-fill) material—A minimum of 5 percent of the dike or levee height.
- For a dike constructed of organic material, as defined by ASTM D-2488, “Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)”—A minimum of 40 percent of the dike height. Organic soils are permitted only for Class III or Class IV dikes with a design high-water height of 6 feet or less.

**Top width and side slopes**
Use table 1 to determine the minimum top width and side slopes for earth embankments.

**Accessibility for maintenance activities**
Maintain accessibility to the dike or levee for maintenance activities. Use NRCS CPS Access Road (Code 560) for access road criteria where required.

**Wave and stability berms**
Refer to table 1 for default widths of constructed wave and stability berms or determine the need for constructed wave or stability berms based on embankment and foundation stability analysis.

For flood control levees, construct wave and stability berms to follow the effective stream gradients (i.e., be parallel to the top of the levee) and slope them away from the levee. For dikes, construct wave and stability berms to have a constant elevation and slope them away from the dike.

For dikes, construct wave and stability berms on each side of the dike where the dike crosses channels, ditches, borrow areas, streams, sloughs, swales, gullies, etc. Construct the top elevation of these berms at least 1 foot above the average ground surface on each side of the channel, ditch, borrow area, stream, slough, swale, gully, etc., and slope the tops of the berms away from the dike.

Use table 1 to determine the minimum top width of natural or constructed berms.

**Dike or levee materials**
Earth materials
Obtain earth materials from required excavations and designated borrow areas. Determine the minimum distance from the toe of the dike or levee to the borrow area so as to not cause instability in the foundation or increase the potential for piping through the foundation.

Manufactured 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. For a dike or levee constructed of manufactured materials, perform a structural analysis for the various loads anticipated during the life of the dike or levee. These loads may include hydrostatic, ice, uplift, seismic, earth, and equipment. Analyze the stability of the dike or levee using acceptable safety factors for each loading condition.

**Embankment and foundation seepage**

Flood-control levee

Base embankment and foundation drainage and seepage control on site investigation, laboratory data, seepage analysis, and stability analysis. Design the embankment to minimize seepage, prevent piping or undermining, and provide a stable embankment and foundation.

Seepage analysis is required on all Class I levees with a design high-water height (H, as defined in table 1) of 6 feet or greater and Class II levees with H equal to or greater than 8 feet.

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

- H < 3 feet—Match height with a 1 foot minimum depth
- H $\geq$ 3 feet—Minimum of 3 feet deep
- Minimum of 4 feet bottom width
- 1:1 or flatter side slopes

Water-level management dike

For all dikes, design the embankment to minimize seepage, prevent piping, or undermining, and provide a stable embankment and foundation.

**Interior drainage**

For a flood prevention levee, provide an interior drainage system to prevent flood damage to the interior area from a flood of the design frequency in table 1 for both the 1-day and 10-day storm duration. Include storage areas, gravity outlets, and pumping plants (NRCS CPS Pumping Plant (Code 533)) in the interior drainage system as needed to provide the required level of flood protection.

**Pipes**

Protect a dike or levee from scour at the pipe inlet and outlet using appropriate measures. If pump discharge pipes are included, install through the dike or levee above the design high-water elevation, if feasible. Equip pump discharge pipes with flexible connections or similar couplings to prevent transmitting vibration from the pumping plant to the discharge pipe.

Equip pipes with flap gates to the anticipated high-water area to prevent inflow into the protected areas. Positive closures for interior drainage are needed in high risk situations.

Class I

For a dike or levee with a design high-water height of 12 feet or greater and pipes below the design high-water elevation, design the pipes in accordance with the principal spillway criteria in NRCS Technical Release No. 60, “Earth Dams and Reservoirs,” except for the minimum pipe size requirements.

For all other Class I dikes or levees with pipes, design the pipe to meet the requirements for a principal spillway in NRCS CPS Pond (Code 378).

Class II and Class III

Design pipes through a Class II levee and a Class III levee or dike according to pipe requirements in NRCS CPS Pond (Code 378). For dikes meeting the Class III exception in table 1, the pipe may be designed according to NRCS CPS Underground Outlet (Code 620).

Class IV

Design pipes through the dike according to pipe requirements in NRCS CPS Pond (Code 378) or NRCS CPS Underground Outlet (Code 620), as appropriate.

**Slope protection**
Protect earth dike or levee slopes from sheet, rill, and gully erosion; and erosion from flowing floodwaters, pipe outfalls, and wave action created by boat traffic or wind. Utilize appropriate erosion protection measures such as vegetation, berms, rock riprap, sand-gravel, or soil cement as needed.

At a minimum, establish a protective cover of grasses on all exposed surfaces of the levee or dike and other disturbed areas according to NRCS CPS Critical Area Planting (Code 342).

**Additional Criteria for Class I Flood-control Levees with a Design High-water Height of Greater Than 12 Feet**

Complete an emergency action plan meeting the requirements of NRCS National Operation and Maintenance Manual (Title 180), Part 500, Subpart F, "Emergency Action Plan," prior to construction for all Class I flood-control levees with a design high-water height of greater than 12 feet. There should be no damages upon failure of a dike, therefore an EAP is not required. If there are damages due to failure, it is no longer a dike, but a levee.

## CONSIDERATIONS

**General Considerations**

**Flood of record**
For a Class I levee consider the flood of record when establishing the top of levee elevation to ensure the level of risk is commensurate with the necessary level of protection.

**Location**
Consider fluvial geomorphological concepts as outlined in the NRCS National Engineering Handbook (NEH) (Title 210), Part 653, "Stream Corridor Restoration Principles, Processes, and Practices," when placing a dike or levee near a stream.

**Wave and stability berms and side slopes**
To protect the dike or levee for its design life, consider using wider berms, additional setbacks, or protecting the berm side slope when adjacent to actively eroding or moving streams.

For dikes constructed for management of wetland wildlife, using side slopes flatter than 5:1 provides a range of water depths used by more wildlife species, especially shorebirds.

**Beaver, Rodent, and Burrowing Animal Control**
Consider the use of chain-link fence or other measures to control burrowing animals.

**Source Water**
Consider providing an increased level of designed treatment for sites with high priority areas for source water protection or are upstream of community drinking water withdrawal sites. Providing an increased level of safety factor can help protect these community water systems.

## PLANS AND SPECIFICATIONS

Prepare plans and specifications that describe the requirements for applying the practice to achieve its intended purpose. As a minimum, include—

- Plan view of site with planned and existing features, including utilities.
- Cross sections and profiles of the planned structure.
- Detail drawings and specifications for all structures and appurtenances, including maintenance access features.
- Material and construction specifications.
- Requirements for foundation preparation, including clearing of vegetation and debris, removing stockpiling topsoil, as appropriate for the site.

- List and describe each type of material used in the various fills in the specifications and drawings.
- Safety concerns.
- Site access for maintenance.
- Vegetation requirements.

## OPERATION AND MAINTENANCE

Develop and provide an operation and maintenance plan to the landowner or project sponsor. The minimum requirements to address include—

- Inspection of the dike or levee and any appurtenant structures annually and following large storm events to ensure there is no damage and that the dike or levee is operating properly.
- Inspection for damage from burrowing animals and to ensure effective rodent control and mitigation of damage caused by burrowing animals.
- Inspection for livestock damage.
- Inspection for any encroachments on the dike or levee.
- Removal of any woody material, debris, or growing timber that compromises the efficient operation or structural integrity of the dike or levee.
- Repairs to the dike or levee as soon as possible after observing damage.
- Reestablishment of vegetative cover on the dike or levee where erosion has removed established vegetation.
- Maintenance of effective erosion control on the contributing watershed drainage area to prevent siltation, as appropriate.

## REFERENCES

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