NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

DIKE

(Ft.)

CODE 356

DEFINITION

A barrier constructed of earth or manufactured materials.

PURPOSE

- 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 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

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 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.

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:

1. For dikes constructed of compacted earth fill material shall be a minimum of 5% of the dike height.
2. 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:

1. 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

2. Layers that are saturated for longer periods, or were saturated before being drained, are organic if:

   (a) They have 12 percent or more of organic carbon and no clay, or

   (b) 18 percent or more organic carbon and 60 percent or more clay, or

   (c) A proportional amount of organic carbon, between 12 and 18 percent, if the clay content is between 0 and 60 percent.

   or

3. 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 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. (see Table 1 for description of “H”)
- Minimum of 3 feet deep for $H\geq3$ feet.
- Minimum of 4 feet bottom width.
- 1:1 or flatter side slopes.

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.

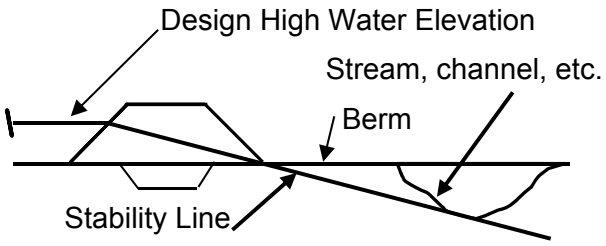

Figure 1

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 NRCS Conservation Practice Standard, Ponds (378). WinPond, or an equivalent procedure, will be used for the hydraulic design of dikes that do not require Technical Release 60 design procedures.

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. Dikes shall be seeded with fescue following the guidelines for Critical Areas in Ohio e-FOTG Appendix A, Section 4, Table 1, Mix 1 or 4. Livestock shall be permanently excluded from all dike surfaces.

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

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.

ADDITIONAL CRITERIA FOR WETLAND DIKES

Wetland dikes are earthfills constructed for the purpose of creating, restoring, or enhancing wetland hydrology. Wetland dikes are classified as Class III dikes. Wetland management is planned under the criteria in NRCS Conservation Practice Standard Wetland Wildlife Habitat Management (644).

The dike top width shall be 8 ft or wider.

Interior embankment slope protection for muskrat damage counter measures will be used as follows:

- 6:1 or flatter for unprotected slopes.
- 3:1 or flatter with wire mesh protection placed on the slope to a minimum of 3 feet below the minimum expected water level. See construction specification for wire mesh slope protection in this standard.
- 3:1 or flatter with aggregate protection placed on the slope to the bottom of the toe of the dike. See the construction specification for aggregate slope protection in this standard.

Use Table 2 to design a dike for wetland creation, restoration, or enhancement.

Dikes will be designed so that the auxiliary flow water levels do not encroach across the neighboring owner's property line unless permission is obtained through an easement. Flows from all spillways shall re-enter the original drainage pattern before it exits the owner's property.

TABLE 2 - Minimum Requirements for Wetland Dikes

Drainage Area (acres)	Effective Height of Embank-ment 1/ (feet)	Total Height of Embank-ment 2/ (feet)	Principal Spillway Design Storm 3/	Auxiliary Spillway Type 4/	Minimum Stage Between Principal & Auxiliary Crests (ft.)	Auxiliary Spillway Design Storm 5/	Freeboard 6/ (feet)
0 - 10	≤ 3	≤ 6	N/A	Vegetated	N/A	Q10	0.5
0 - 20	< 6	≤ 6	Q2	Vegetated	0.5	Q10	0.5
			N/A	Armored	N/A		
20 - 100	< 6	≤ 6	Q2	Vegetated	1.0	Q25	1.0
			N/A	Armored	N/A		
>100		>6	Use Practice Standard 378- Pond				

1/ Effective Height of the embankment is defined as the difference in elevation from the crest of the auxiliary spillway to the lowest point of the original ground along the centerline of the embankment.

2/ Total Height of the embankment is defined as the difference in elevation from the settled top of the embankment to the elevation of the natural streambed at the downstream or outside toe of the embankment. Maximum allowable storage capacity is 50 ac-ft (measured at the auxiliary spillway crest).

3/ Principal Spillway Design Storm

a. N/A- Principal spillway pipe is not required but a water control structure may be used for water level management per standard 644. The water level shall not be set above the design permanent pool elevation.
b. Q_2- The 2-year storm produces no flow in the auxiliary spillway. Storage and/or principal spillway discharge must handle the 2-year design storm.
c. A stop-log structure will be allowed to serve as a principal spillway only when the maximum design permanent pool elevation is clearly marked on the drawings and all animal guard/trash rack components are likewise shown on the drawings.
d. All water control structures must have an adequate outlet that conveys capacity flows.

4/ Auxiliary Spillway Type
   a. Vegetated-spillway cross section is seeded with grass.
   b. Armored- spillway section from inlet of the control section to beyond the toe of the dike is designed to be stable with riprap. Stability shall be documented in the design folder.
      i. If an armored auxiliary spillway is used, a principal spillway pipe is not required.

5/ Auxiliary Spillway Design Storm
   a. Q_{10}- 10-yr frequency/24-hr duration storm
   b. Q_{25}- 25-yr frequency/24-hr duration storm

   The auxiliary spillway design storm may be routed taking into account flood storage and principal spillway flow. Credit for principal spillway flow during the auxiliary spillway design storm requires a pipe diameter of at least 10 inches and a pipe inlet crest elevation such that the design discharge will be generated in the conduit before there is discharge through the auxiliary spillway.

6/ Freeboard is defined as the difference in elevation between the top of the settled embankment and the maximum water elevation at the design auxiliary spillway discharge.

CONSIDERATIONS

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

Location. When locating the site for the dike, consider 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.

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.

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.

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.

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.

Additional Operation and Maintenance for wetland dikes

- Dikes shall be mowed and checked for rodent damage at least once a year, and rodent damage shall be promptly repaired. When rodent damage is frequent, measures for rodent removal need consideration.
- Prevent the pool water elevation from remaining above the designed permanent pool elevation through various occurrences. These occurrences include inappropriately adjusting the principal spillway structure or letting trash build up on the inlet or control structure.
- O&M shall include operational procedures planned under NRCS Conservation Practice Standard Wetland Wildlife Habitat Management (644) criteria.

References

Storm routing tools include the 190 series design worksheets based on NRCS Engineering Field Handbook, Chapters 3, 6 and 11 and software programs such as WinPond, Sites, WinTR-55 and WinTR-20. The software programs are available at the NRCS "Science and Technology Conservation Tools Software" website:
http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/ndcsmc/?cid=stelprdb1042198

and/or the NRCS "H & H Tools and Models" website (http://go.usa.gov/KoZ).

NATURAL RESOURCES CONSERVATION SERVICE
CONSTRUCTION SPECIFICATION

DIKE – 356

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 carried out in a manner to minimize air and water pollution. Bare areas shall be re-vegetated as soon as practical after earthwork is completed. A minimum area should be stripped of vegetation at any one time to provide an adequate work site.

Disposal of debris from site preparation shall be done in a manner to cause minimum pollution to the environment.

Foundation Preparation

The foundation area shall be cleared of all trees, stumps, roots, brush, boulders, sod, and debris. The foundation area will be stripped to a minimum depth of 6 inches. All pockets of organic soil, sand, gravels, and other unsuitable material will be removed. After excavation is complete, all slopes within the foundation area will be no steeper than 1:1. The surface of the foundation area shall be thoroughly scarified before placement of the embankment material.

The cutoff trench shall be excavated to lines and grades as shown on the plans. It shall be backfilled with suitable material in a manner as specified for earth embankment. The trench shall be kept free of standing water during backfill operations.

Conduit Installation

All conduits through a dike shall be placed on a firm foundation to the lines and grades shown on the plans. Selected backfill material shall be placed in layers around the conduits and their component parts and each successive layer shall be thoroughly compacted.

Embankment Construction

Borrow areas shall be shown on the drawings or embankment material obtained from a source approved by individual with job approval authority.

Earthfill Compaction

Prior to beginning placement of earth fill, the surface of the foundation area will be scarified to a depth of 4 inches and compacted to the same requirements as specified for earth fill. All areas upon which earthfill is placed will be dewatered prior to placement.

Fill material will be obtained from designated borrow area(s) and shall be free of all sod, roots, frozen soil, stones larger than 6 inches diameter, and other objectionable material. The placing and spreading of the fill material shall begin at the lowest point in the foundation area and shall be placed in horizontal lifts. The thickness of each lift prior to compaction shall be the minimum of the length of the cleats on the sheepsfoot roller plus three inches or nine inches. Unless otherwise specified on the plans, each lift will be compacted with at least four passes of a sheepsfoot roller (200-psi minimum rating) equipped with cleat cleaners.

The distribution and gradation of materials throughout the fill shall be such that there will be

no lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material. Where it is necessary to use materials of varying texture and gradation, the more impervious material shall be placed in the upstream and center portions of the fill.

The moisture content of the fill material being placed must be maintained within the limits required to permit satisfactory compaction. The lower moisture content limit is the amount of moisture required to produce a hand-molded ball that holds its shape. The upper moisture content limit is the amount of moisture required to disable operation of compaction equipment. If borrow material is dry, water must be added by irrigating the borrow area or by sprinkling each fill layer prior to compaction. After adding water, the fill material must be mixed to obtain uniform moisture content prior to compaction. Material that is too wet when placed on the fill shall be removed or dried by disking prior to compaction.

If the top surface of the preceding layer of compacted fill or abutment surface in the zone of contact with the fill becomes too dry to permit a suitable bond, it shall be scarified and moistened by sprinkling to an acceptable moisture content prior to placement of the next layer of fill.

If the top surface of the fill becomes too set or frozen, this material must be removed prior to placement of the next layer of fill.

Dumped fill, where used, shall be placed in layers or deposited in a manner suitable to the equipment used and the material excavated. Shaping shall be done so as to break up lumps and clods of earth. Excessively wet material shall be placed to permit free drainage and shaped after it has drained. When the fill slumps due to wetness, the dike shall be constructed in stages.

Conduit and Structure Earthfill

The moisture content for earthfill placed around all conduits installed in or under the dike shall be the same as for Earthfill Compaction. The maximum rock size shall be 4 inches. Earthfill material shall be placed in uniform horizontal layers not to exceed 6 inches prior to compaction. Compaction of the fill shall be done by exerting pressure over the entire upper surface of each lift with a mechanical hand-operated compactor. Plate compactors shall not be used. No construction equipment shall be operated within two feet of any conduit or structure. The alignment and grade of flexible pipe conduits shall be maintained during compaction to prevent displacement.

For Wetland Dike Water Control Structures

Pre-fabricated flashboard type water level control structures shall have a locking cap and be protected from freezing. Flashboards shall be set not higher than maximum permanent pool elevation.

Slope Protection – Wire Mesh

Wire mesh protection will extend from a minimum of three feet (vertically) below the minimum expected pool elevation to the top interior shoulder of the embankment and shall extend along the entire interior constructed embankment slope between abutment contacts with original ground.

Place chain link fence fabric or welded wire fence fabric on the interior, constructed embankment slope. All fence fabric shall be new unused materials from the vender.

a. Chain link fence fabric shall conform to the requirements of ASTM A 392, 2-inch mesh and 9-gauge galvanized steel wire. Zinc coating shall be class 2.

b. Welded wire fence fabric shall be 2-inch by 2-inch maximum mesh size conforming to ASTM F 2453 Type 2.

Topsoil or mineral soil shall be spread over the fence mesh 6-inches thick measured perpendicular to the slope. The surface protection shall be secured to the ground so no displacement occurs during spreading of the six-inch cover.

Fence fabric panels shall be spliced at the ends and edges by one of the following methods. Fence fabric panels shall be placed and positioned on the embankment slope in their final location prior to splicing.

Method 1 - Install bypass ring type fasteners to connect the wires on the edges and ends of adjoining welded wire fabric panels. Chain link panels shall be over lapped at least two mesh widths and connections made between edge wires to interior side panel wires of adjacent panels. Bypass ring type fasteners shall be galvanized or stainless steel and shall be crimped to produce at least a ¾-inch bypass between ring ends measured along the circumference of the ring. Install bypass rings at spacing not greater than six-inches.

Method 2 - Install reinforcing bar galvanized, 14 gauge, tie wire or wire tie connectors to connect the wires on the edges and ends of adjoining welded wire fabric panels. Chain link panels shall be over lapped at least two mesh widths and connections made between edge wires to interior side panel wires of adjacent panels. Secure each connector tightly around panel wires with at least two full twists. Install connectors at spacing not greater than six-inches.

Method 3 - Use reinforcing bar, 14 gauge, galvanized tie wire to lace together the wires on the edges and ends of adjoining welded wire fabric panels. Chain link panels shall be over lapped at least two mesh widths and connections made between edge wires to interior side panel wires of adjacent panels. Lace panels together by making a half-hitch around wires on adjoining panels at spacing not less than six-inches.

Slope Protection - Aggregate

Interior slope aggregate protection will extend from the toe of the dike to the top interior shoulder of the embankment and shall extend along the entire interior constructed embankment slope between abutment contacts with original ground.

Place a layer of aggregate on the interior, constructed embankment slope.

Aggregate shall be size No. 1 or 2 aggregate conforming to AASHTO M 43.

Layer thickness shall be nine inches.

The aggregate layer will be equipment placed to the specified thickness in one operation on the constructed interior slope of the dam.