NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

DIKE

(Ft.)

CODE 356

DEFINITION

An embankment constructed of earth or other suitable materials to protect land against overflow or to regulate water.

PURPOSE

To permit improvement of agricultural land by preventing overflow and better use of drainage facilities, to prevent damage to land and property, and to facilitate water storage and control in connection with wildlife and other developments. Dikes can also be used to protect natural areas, scenic features, and archeological sites from damage.

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 comparison to the surface area of the regulated water level.

CRITERIA

General

In locating dikes, careful consideration shall be given to preserving natural areas, fish and wildlife habitat, woodland, and other environmental resources. Where dike construction will adversely affect the above resources, concerned public agencies and private organizations shall be consulted about the project.

Protection

A protective cover of grasses shall be established on all exposed surfaces of the dike and other disturbed areas. Seedbed preparation, seedings, fertilizing, mulching, and fencing shall comply with recommendations in Conservation Practice Standard, Critical Area Planting, 342.

If vegetation will not control erosion, riprap or other protective measures shall be installed.

Location

The centerline of the dike cross-section shall not be installed closer than a minimum distance from the top of the near toe of channel slope. The minimum distance is one half of the top width plus two and one half times the vertical distance from the planned constructed top of dike and the lowest of the existing or planned grade invert of the channel plus the width of any channel side berm.

Soils Explorations

Subsurface geologic explorations will be made for all dikes to determine the composition and extents of soils in the planned dike foundation and all borrow areas. Explorations for Class I and II dikes shall be planned, conducted, and interpreted by a competent engineering geologist or registered professional engineer. Foundation soils shall be investigated to a depth of the design water depth of the dike below natural ground level plus two feet. Test pits or borings shall be made on a maximum spacing of one thousand feet along the planned centerline of the dike. The spacing may need to be decreased due to the complexity of the soils.

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 Dikes

Those dikes constructed on sites where one or more of the following conditions apply:

1. Failure may cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, main highways or railroads, and high value land, crops, or other improvements.

2. Unusual or complex site conditions require special construction procedures to ensure satisfactory installation.

3. Protection is needed to withstand more than 12 feet of water above normal ground surface, exclusive of crossings of sloughs, old channels, or low areas.

Class II Dikes

Those dikes constructed in highly developed and productive agricultural areas where:

1. Failure may damage isolated homes, highways or minor railroads, or cause interruption in service of relatively important public utilities.

2. The maximum design water stage against the dike is 12 feet.

Class III Dikes

Those dikes constructed in rural or agricultural areas where:

1. Damage likely to occur from dike failure is minimal.

2. The maximum design water stage against the dike is 6 feet for mineral soils and 4 feet for organic soils. (Exclude channels, sloughs, swales, and gullies in determining the design water stage.)

DESIGN CRITERIA – CLASS I DIKES

Location
Conditions to be considered in designing Class I dikes are foundation soils, property lines, exposure to open water, adequate outlets for gravity or pump drainage, and access for construction and maintenance. Mineral soils that will be stable in the dike embankment must be available for construction.

Height
The design height of the dike shall be the design high water depth plus 2 feet of freeboard or 1 foot of freeboard plus an allowance for wave height, whichever is greater. Design elevation of high water shall be determined as follows:

- If dike failure is likely to cause loss of life or extensive high-value crop or property damage, the elevation of design high water shall be that associated with the stage of the 100-year-frequency flood or of the maximum flood of record, whichever is greater.

- If dike failure is unlikely to result in loss of life or extensive high-value crop or property damage, the elevation of design high water shall be that associated with the peak flow from the storm that will ensure the desired level of protection or the 50-year-frequency flood, whichever is greater.

- If the dike will be subject to stage from more than 1 stream or source, the criteria indicated shall be met for the combination that causes the highest stage.

The design height of the dike shall be increased by the amount needed to ensure that the design top elevation is maintained after settlement. This increase shall not be less than 5 percent.

Interior Drainage
If the inflow from the area to be protected by the dike may result in loss of life or extensive high-value crop or property damage, provisions shall be included in the plans to provide interior protection against a 100-year-frequency hydrograph, plus base flow, and an allowance for seepage, and may include storage areas, gravity outlets, or pumping plants, alone or in combination.

If inflow from the area to be protected by the dike is unlikely to result in loss of life or extensive high-value crop or property damage, storage areas, gravity outlets, or a pumping plant, along or in combination, shall be included in the plans and designed to handle the discharge from the drainage area based on drainage requirements established for the local area or the peak flow from the storm that will ensure the desired level of protection, whichever is greater.

In sizing outlet works in combination with available storage, the minimum design storm duration for interior drainage shall be 10 days. If outlet works are designed using peak flood frequency flows without considering storage, the minimum design storm duration shall be 24 hours.

Embankment and Foundation

The embankment shall be constructed of mineral soils, which when placed and compacted will result in a stable earth fill. No organic soil shall be used in the dike. Soils must have high specific gravity and be capable of being formed into an embankment of low permeability. The design of the embankment and specifications for its construction shall give due consideration to the soil materials available, foundation conditions, and requirements for resisting the action of water on the face of the dike and excessive seepage through the embankment and the foundation. The design of the embankment and the foundation requirements shall be based on the length of time and height that water will stand against the dike.

Minimum requirements for certain features of the embankment, the foundation, and borrow pits are as follows:

Minimum top width of Class I dikes shall be 10 feet for embankment heights of 15 feet or less and 12 feet for heights more than 15 feet. If maintenance roads are to be established on the dike top, “turnarounds” or passing areas shall be provided, as needed.

Side slopes shall be determined from a stability analysis, except that an unprotected earth slope on the water side shall not be steeper than 4 horizontal to 1 vertical if severe wave action is anticipated.

If dikes cross old channels or have excessively porous fills or poor foundation conditions, the landside toe shall be protected by a banquette or constructed berm. Banquettes shall be used to provide construction access and added stability if channel crossings are under water or saturated during construction. Banquettes shall be designed on the basis of site investigations, laboratory analysis, and compaction methods. The finished top width of the banquettes shall not be less than the height of dike above mean ground. The finished top of the banquettes shall be not less than 1 foot above mean ground and shall be sloped away from the dike.

A cutoff shall be used if foundation materials are sufficiently pervious to be subject to piping or undermining. The cutoff shall have a bottom width and side slopes 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 previous foundations are too deep to be penetrated by a foundation cutoff, a drainage system adequate to ensure stability of the dike shall be used.

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 waterside of dikes shall be wide and shallow.

Plugs, at least 15 feet in width, shall be left in the ditches at intervals not greater than 400 feet to form a series of unconnected basins.

Minimum berm widths between the toe of the dike and the edge of the excavated channel or borrow shall be:

Fill Height	Minimum Berm Width
Less than 6 feet	12 feet
More than 6 feet	18 feet

Drainage Systems

A drainage system shall be used if necessary to ensure the safety of a dike. Toe drains, if used, shall be located on the landside and shall have a graded sand-gravel filter designed to prevent movement of the foundation material into the drain.

Subsurface drains shall not be installed, or permitted to remain without protection, closer to the landside to e of a dike than a distance 3 times the design water height for the dike. If subsurface drains are to be installed or remain closer than the distance stated, protection shall consist of a graded sand-gravel filter, as for a toe drain, or a closed pipe laid within the specified distances from the dike.

Pipes and Conduits

Dikes shall be protected from scour at pump intakes and discharge locations by appropriate structural measures. A pump discharge pipe through a dike shall be installed above design high water, if feasible, or be equipped with antiseep collars.

All conduits through a dike below the design high waterline shall be equipped with antiseep collars designed to increase the distance of the seepage line along the conduit by at least 15 percent. Discharge conduits of pumps placed below the designed waterline shall be equipped with a Dayton or a similar coupling to prevent vibration of the pumping plant being transmitted to the discharge conduits.

DESIGN CRITERIA – CLASS II DIKES

Design Water Stage

The maximum design water stage permitted is 12 feet above normal ground level exclusive of crossings at channels, sloughs, and gullies.

If the design water depth against dikes, based on the required level of protection exceeds 4 feet, the design shall be based on at least a 25-year-frequency flood. If this degree of protection is not feasible, the design shall approach the 25-year flood level as nearly as possible, and planned fuse plug sections and other relief measures shall be installed where appropriate.

Height

The design height of an earth dike shall be the design water depth plus a freeboard of at least 2 feet or freeboard of 1 foot plus an allowance for wave height, whichever is greater.

The constructed height of the dike shall be the design height plus an allowance for settlement necessary to ensure that the design top elevation is maintained but shall be no less than 5 percent of the design height.

Interior Drainage

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

Cross Section

The minimum requirements for the cross section of the dike where fill is compacted by hauling or special equipment shall be as follows:

Design Water Height	Minimum Top Width	Steepest Side Slope
Ft	Ft	
0- 6	8	2:1
6-12	10	2-1/2:1

If soils or water conditions make it impractical to compact the dike with hauling or special equipment, dumped fill may be used and shall have minimum cross section dimensions incorporated in the fill as follows:

Design Water Height	Minimum Top Width	Steepest Side Slope
Ft	Ft	
0- 6	8	2:1
6-12	10	2-1/2:1

Side slopes of 3 horizontal and 1 vertical on waterside and 2:1 on landside may be used instead of 2-1/2:1 for both slopes.

The cross sections shall be strengthened or increased as required to provide additional protection against floods of long duration. The top width shall be not less than 10 feet if a maintenance road is planned on top of the dike. “Turnarounds” or passing areas shall be provided as required on long dikes.

The side slopes shall be 3:1 or flatter on the waterside if severe wave action is expected or if a steeper slope would be unstable under rapid drawdown conditions. Side slopes shall be 3:1 or flatter on both sides where permeable soils of low plasticity, such as SM and ML, are used in construction.

A banquette or constructed berm shall reinforce the landside toe if a dike crosses an old channel or if excessively porous fill or poor foundation conditions justify such reinforcement. Such banquettes shall be used if, during construction, the channel crossing is under water or saturated. The top width of the banquette shall be equal to or greater than the fill height of the dike above the top of the banquette unless a detailed investigation and analyses show a different design is adequate

Foundation Cutoff
A cutoff shall be installed if there are layers of permeable soils or layers creating a piping hazard through the foundation at a depth less than the design water depth of the dike below natural ground level. The cutoff trench shall be of sufficient depth and width and filled with suitable soils to minimize such hazard.

Ditches and Borrow Pits
Minimum berm widths between the toe of the dike and the edge of the excavated channel or borrow shall be:

Fill Height	Minimum Berm Width
Less than 6 feet	12 feet
More than 6 feet	15 feet

A landslide ditch or borrow pit shall be far enough away from the dike to minimize any hazard to the dike because of piping through the foundation.

For dikes having a design water depth of more than 5 feet, the landside ditch or borrow pit shall be far enough away from the dike so that a line drawn between the point of intersection of the design waterline with the waterside of the dike and the landside toe of a dike meeting minimum dimensional requirements shall not intersect the ditch or borrow pit cross section.

Pipe and Conduits
The dike shall be protected from scour at a pump intake and discharge by appropriate structural measures. A pump discharge pipe through the dike shall be installed above design high water, if feasible, or else equipped with antiseep collars.

All conduits through the dike below the design high waterline shall be equipped with antiseep collars designed to increase the distance of the seepage line along the conduit by at least 15 percent. Discharge conduits of pumps placed below the designed waterline shall be equipped with a Dayton or a similar coupling to prevent vibrations of the pumping plant being transmitted to the discharge conduits.

Drains
Drains shall be used where necessary to ensure safety of dikes and shall be located on the landside, have a graded sandgravel filter, and be designed and installed in accordance with NRCS standards for such drains.

Field 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. If such drains are to be installed or remain closer than the distance stated above, protection shall consist of a graded sandgravel filter, as for a toe drain, or a closed pipe laid within the specified distances from the dike.

DESIGN CRITERIA – CLASS III DIKES

Design criteria shall be based on site conditions as determined by engineering surveys and investigations.

Top Width
Minimum top width is 4 feet.

Side Slopes
Minimum side slope is 1-1/2:1 for mineral soils and 1:1 for organic soils.

Freeboard
The minimum freeboard is 1 foot plus wave height. The constructed height shall be increased by the amount necessary to ensure that the settled top is at design elevation but not less than 5 percent.

Foundation Cutoff
A cutoff shall be installed if necessary to ensure dike stability.

Ditches, Berms, and Borrow Pits
Minimum berm widths between the toe and the dike and the edge of the excavated channel or borrow shall be 2 times the depth of the ditch but not less than 8 feet.

CONSIDERATIONS

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.

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.

PLANS AND SPECIFICATIONS – ALL DIKES

Plans and specifications for constructing dikes shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

OPERATION AND MAINTENANCE

All dikes must be adequately maintained to the required shape and height. The maintenance of dikes must include periodic inspections to determine maintenance required to maintain high quality herbaceous vegetative cover. Maintenance will include supplemental applications of fertilizer, mowing, control of livestock, etc. as required. Provisions for maintenance access must be provided.

NATURAL RESOURCES CONSERVATION SERVICE
CONSTRUCTION SPECIFICATION

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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 is 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. All channel banks and sharp breaks shall be sloped no steeper than 1:1. Topsoil that is high in organic matter shall be removed. The surface of the foundation area shall be thoroughly scarified before placement of the embankment material.

The cutoff trench, where used, 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 necessary degree of compaction shall be obtained by using equipment adapted to site conditions. 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
The embankment material may be obtained from a selected borrow area or from a channel.

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).

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 pond, 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.