NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

POND

(NO.)

CODE 378

DEFINITION

A water impoundment made by constructing a dam or an embankment or by excavating a pit or dugout.

In this standard, ponds constructed by the first method are referred to as embankment ponds and those constructed by the second method as excavated ponds. Ponds constructed by both the excavation and the embankment methods are classified as embankment ponds if the depth of water impoundment against the embankment at spillway elevation is 3 ft. or more.

PURPOSE

Ponds are constructed to provide water for livestock, fish and wildlife, recreation, fire control, crop and orchard spraying, and other related uses.

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to ponds located in predominantly rural or agricultural area when:

- Failure of the structure would not result in loss of life; in damage to homes, commercial, or industrial buildings, main highways, or railroads; or in interruption of the use or service of public utilities. (Dam of hazard class “a”).
- The product of the storage times the effective height of the dam does not exceed 3,000. Storage is defined as the volume (acre-feet) in the reservoir below the elevation of the crest of the auxiliary spillway. Effective height of the dam is defined as the difference in elevation (feet) between the auxiliary spillway crest and the lowest point in the cross section taken along the centerline of the dam.
- The vertical distance between the lowest point along the centerline of the dam and the crest of the auxiliary spillway does not exceed 35 feet.
- Site conditions are such that the runoff from the design storm (see section F.2. “Auxiliary Spillway, Capacity”) can be safely passed through (1) a natural or constructed auxiliary spillway, (2) a combination of a principal spillway and an auxiliary spillway, or (3) a principal spillway.
- The drainage area above the pond has been protected against erosion to the extent that expected sedimentation will not shorten the planned effective life of the structure. The drainage area shall be large enough that surface runoff and groundwater flow, will maintain an adequate supply of water in the pond and the quality of the water delivered to the site is suitable for its intended use.
- The reservoir topography of the site will permit storage of water at a depth and volume which insures a dependable supply, considering beneficial use, sedimentation, season of use, and evaporation and seepage losses.
- Reservoir soils, where surface runoff is the primary source of water for a pond, are impervious enough to prevent excessive seepage losses or are of a type that sealing is practicable.

EMBANKMENT PONDS

Design Criteria

The design and construction of a structure shall comply with all state and local laws.

Foundation

The area on which a dam is to be placed shall consist of material that has sufficient bearing strength to support the dam without excessive consolidation. The foundation should consist of, or be underlain by, relatively impervious material which will prevent excessive passage of water.

Foundation Cutoff

A cutoff trench, located at or upstream of the centerline shall be provided under all dams. It shall be backfilled with relatively impervious material and compacted to the specified requirements.

The cutoff trench shall be deep enough to extend into a relatively impervious layer for positive cutoff or be combined with seepage control to provide for a stable dam.

It shall extend up the abutments, as required, and have a bottom width adequate to accommodate the equipment used for excavation, backfill, and compaction operations. The side slopes shall not be steeper than 1:1.

On small dams which do not ordinarily require a detailed geologic investigation, a cutoff trench with a minimum depth of 3 feet, shall be constructed in the foundation. This minimum depth will be deepened when necessary, to completely cut through the root zone and to cut off any network of rodent holes and small animal burrows.

The depth of the cutoff trench may also be determined by a geologic investigation.

Seepage Control

Seepage control is to be included if: (1) pervious layers are not intercepted by the cutoff, (2) seepage may create a swamping effect down-stream, (3) needed to insure a stable embankment, or (4) special problems require drainage for a stable dam. Seepage control may be accomplished by: (1) foundation, abutment or embankment drains, (2) reservoir blanketing, or (3) a combination of these measures.

When using drains which include a conduit as a component for seepage control, the criteria in Table 1 shall be used.

Table 1 - Depth Of Fill Over Drain Conduits Encased In Sand Or Gravel

Material	Diameter	Minimum Gage or Thickness of Material	Max Depth of Fill (ft)
PVC1120 or PVC 1220 1/	3” & 4”	SDR-26(160 psi) SDR-21(200-psi)	16’
Corrugated Steel Pipe (Spiral)	6”	16 ga.	35’

1/ Conforming to ASTM D-785 and/or ASTM 2241.

Earth Embankment

The minimum top width of a dam is governed by the total height of the dam and whether it is to be used for public transportation. Minimum top width is shown in Table 2.

Table 2 - Minimum Top Width Of A Dam Compared To Total Height And Transportation Usage

Use	Total Height (Feet)	Top Width (Feet)
Agricultural		
	24.9 or less	12
	25.0 34.9	14
	35 and more	15
Embankment Used For Public Road		
Guardrails or other safety measures are to be used where necessary and are to meet the requirements of the responsible road authority	one-way traffic two-way traffic	16 28

Side Slopes

The upstream and downstream side slopes of the settled embankment shall be not less than

2.5:1 from the overfill elevation of the top of the dam. Slopes must be designed to be stable in all cases.

Wave Erosion Protection

Where needed to protect the face of the dam, special wave protection measures, such as berms, rock riprap or special vegetation, shall be provided.

When the permanent pool exceeds 5 acres, a berm, with a minimum width of 10 feet, shall be used at the elevation of the pool, and the upstream slope below this elevation shall be not steeper than 2.5:1. For maximum protection, a 4:1 slope is preferred. In no case will the slope below the berm be steeper than the slope above the berm. Where the surface area of the pool exceeds 15 acres or the direct fetch exceeds 1800 feet, riprap, 12:1 berm slopes, or other approved slope protection will generally be required.

Freeboard

The minimum elevation of the top of the settled embankment shall be 1.0 foot above the water surface in the reservoir with the auxiliary spillway flowing at design depth.

The minimum difference in elevation between the crest of the auxiliary spillway and the settled top of the dam shall be 2.0 feet.

Allowance for Settlement

The design height of the dam shall be increased by the amount needed to insure that, after all settlement has taken place, the height of the dam will equal or exceed the design height. This increase shall be not less than 5 percent, except where detailed soil testing and laboratory analysis shows a lesser amount is adequate.

Revegetation

All of the embankment, borrow above the permanent water level, auxiliary spillway and other disturbed areas shall be seeded as part of each job.

Principal Spillway

1. General

   a. A principal spillway shall be installed when any one of the following conditions exists: (1) when the classification of the auxiliary spillway according to the Nebraska supplement entitled "Emergency and Principal Spillway Proportioning Guide" in chapter 2 of the Engineering Field Manual so requires or (2) when required by the Nebraska Department of Water Resources.

   b. In structures where no principal spillway is required, based on the "Proportioning Guide," but which have intermittent springs or seeps flowing into them, a plastic or steel pipe should be installed to handle the base flow. The minimum size of this pipe is to be 4 inches.

2. Size

The size of the principal spillway conduit shall be determined, based on requirements of the "Proportioning Guide."

Where available, detention storage should be considered in the design of the principal spillway and an appropriate method of flood routing shall be used for principal spillway design.

When the principal spillway is designed without allowing for detention storage, the size of conduit shall be determined by using the appropriate percentage of the auxiliary spillway storm as selected from the proportioning guide.

The minimum size of principal spillway shall be:

Drop Inlet:	Minimum diameter 12"
Hood Inlet (straight):	Minimum diameter 8"
Hood Inlet (with elbows):	Minimum diameter 12"

The maximum size of principal spillway shall be:

Drop Inlet:	Maximum diameter 48"
Hood Inlet:	Maximum diameter 36"

3. Riser

The minimum diameter of the riser shall be 24" or 1.25 times the diameter of the barrel, whichever is larger. When a plate or valve is used on a drawdown pipe or when a riser with stop log or pipe flow control is used, a riser of greater diameter may be required to provide access.

The riser base shall be reinforced concrete with the following exception. Structural steel riser bases may be used only at remote sites where the topography and hauling distance is such that use of concrete bases are prohibitive. Steel bases shall not be used on risers larger than 30 inches in diameter. A minimum 10 ft x 10 ft square berm at the riser crest elevation is required when a structural steel riser base is used.

4. Crest Elevation of Inlet

The crest elevation of the inlet or riser shall be such that full flow will be generated in the barrel before there is discharge through the earth auxiliary spillway.

The crest elevation of the inlet will be not less than 1.0 foot below the crest of the earth auxiliary spillway.

5. Outlet

A pipe support or pier shall be used to support the cantilevered outlet of the barrel when present or future conditions at the outlet end of pipe may not be adequate to provide firm support. The pipe support should be placed at the intersection of the downstream slope of the embankment and the flowline of the outlet channel projected upstream. The cantilever length shall extend beyond the pipe support and shall be a minimum of 3.0 feet above the flowline of the outlet channel.

See Table 3 for the requirements for the maximum unsupported or cantilevered lengths of corrugated metal pipes.

A pipe support may not be required if the downstream channel is stable or a scour hole is not likely to develop due to low peak discharges. When a pipe support is not used, the pipe shall extend not less than 3 feet beyond the point where the downstream slopes of the embankment intersect the flowline of channel, projected upstream. The outlet end of barrel shall be placed a minimum of 2.0 feet above the flowline of the channel. If aggrading or siltation in the channel is possible, then the outlet end of pipe should be raised.

6. Pipe Conduit

All pipe lengths and coupling bands shall be watertight.

The following materials are acceptable: plastic, welded steel, corrugated metal (annular or spiral) or other approved material of a strength or gage specified as safe for the height of fill over the top of the pipe.

Maximum design fill heights for plastic, steel and aluminum pipe are to be determined from an appropriate engineering analysis.

In the absence of an engineering analysis, the maximum fill heights in table 3 are to be followed.

TABLE 3

Material	Diameter	Gauge or Thickness of Material	Max Depth of Fill (ft) Over Pipe
1. PVC 1120 or PVC 1220 1/	4”	2/ SDR 26	10
		SCHEDULE 40	15
		SCHEDULE 80	20
	6”,8”,10”,12”	SCHEDULE 40	10
		SCHEDULE 80	15
		SDR 17	15
		SDR 21	12.5
		SDR 26	10
		SDR 51	5 3/
2. WELDED STEEL PIPE (Coal Tar or Asphalt Coated)	16”	.312”	25
	20”	.438”	25
3. CORRUGATED STEEL PIPE (Spiraled or Annular) (2-2/3” x 1/2” corrugation)	24” or less	16 ga	25
	30”	16 ga	20
		14 ga	25
MAXIMUM LENGTH OF CANTILEVER OUTLET SECTION (FOR ALL GAUGES) SHALL BE 8 FT.	36”	14 ga	20
		12 ga	25
	42”	12 ga	20
		10 ga	25
	48”	10 ga	25
4. CORRUGATED STEEL PIPE (Spiraled or Annular) (3” x 1” corrugations)	36”	16 ga	25
		14 ga*	25
	42”	16 ga	25
		14 ga	25
	48”	16 ga	20
		14 ga	25
		12 ga*	25
MAXIMUM LENGTH OF CANTILEVER OUTLET SECTIONS SHALL BE 5FT, EXCEPT THOSE INDICATEDBY (*) WHICHMAY BE 8 FT.	54”	16 ga	20
		12 ga*	25
	60”	16 ga	15
		14 ga	20
		10 ga*	25
	66”	16 ga	15
		14 ga	20
		8 ga*	25
	72”	16 ga	15
		14 ga	20
		8 ga*	25
5. ALUMINUM CORRUGATED METAL PIPE	Less than 21”	.060”	25
(2-2/3” x 1/2” corrugation)	24”	.060”	15
		.075”	20
		.105”	25
	30”	.075	15
		.105	20
		.135	25

1/ Conforming to ASTM D1785 and/or ASTM 2241
2/ SDR = outside diameter/wall thickness
3/ SDR 51 restricted to use as inlets to excavated ponds

Asphalt coating, 10-mil polyvinyl coating, or other approved coating shall be required for corrugated steel pipes installed in all soils with a resistivity of 4000 ohms or less.

Cathodic protection normally should be provided for corrugated steel pipe where the saturated soil resistivity is less than 2500 ohms/cm and must be provided if less than 1500 ohms. The Nebraska supplement to Chapter 6 of the Engineering Field Manual provides criteria for cathodic protection design.

7. Seepage along pipes extending through embankment (including water supply lines) shall be controlled by use of antiseep collars or sand diapraghms.

   a. Antiseep Collars

      Protection against seepage along the outside of the barrel may be provided by antiseep collars. They shall be constructed of approved material, compatable with and equally durable to the pipe material. The number of collars and projection shall be determined from the length of pipe barrel that lies in the saturated zone of the earth embankment in accordance with the following formula:

$$N = \frac{(25 + 2.5h)(0.15)}{2P}$$

      Where:

      N = number of collars (rounded up)

      *h =Maximum height of embankment

      P = projected height of collar (normally 2.0 ft to 2.5ft)

      The saturated zone is defined as 25 + 2.5h. (Foundation drains may reduce this).

      *For hood inlets where permanent water is expected to be below the pipe inlet, h may be taken as the height from the top of dam to flowline of the pipe at the centerline of the structure.

      Antiseep collars shall be spaced at not more than 25 foot centers. If only one is used, it should be placed not more than 25 feet from the riser. Antiseep collars shall be watertight where two piece collars overlap and also at their connections to the pipe.

   b. Sand diaphragms

      The sand diaphragm is to consist of sand, meeting fine concrete aggregate requirements (at least 15% passing the No. 40 sieve but no more than 10% passing the No. 100 sieve). If unusual soil conditions exist, a special design analysis shall be made.

      The sand diaphragm shall be a minimum of 2 foot thick and extend vertically upward and horizontally at least 3 times the pipe diameter. They shall extend vertically downward at least 18 inches beneath the conduit invert. The sand diaphragm shall be located immediately downstream of the cutoff trench, approximately parallel to the centerline of the dam.

      The sand diaphragm shall outlet at the embankment downstream toe, preferably using a drain backfill envelope continuously along the pipe to where it exits the embankment. Protecting drain fill from surface erosion will be necessary.

8. Antivortex Device Trash Guard

An antivortex device shall be used on all risers and hood inlets. A trash guard shall be used in those locations where vegetation or debris in the drainage area above the structure indicates a need. It may also be used as a safety measure.

Standard drawings are available for conical trash racks with antivortex devices for risers less than 36 inches and for steel-angle debris guards with splitter walls for risers larger than 36 inches.

9. Slope of Barrel

Drop Inlets: When the slope of the barrel is uniform throughout its entire length, a minimum slope of 1 foot per 100 feet is required for a final (after foundation settlement) grade to provide drainage. The maximum barrel slope without a break in grade shall be 7 percent. When the grade exceeds 7 percent and an elbow is used at the upper end of the outlet section of pipe, the slope of the outlet pipe shall be not greater than 4 percent nor less than 3 percent.

Hood Inlets: The slope of the barrel shall not exceed 36 percent, and the grade of outlet section shall be limited as for “Drop Inlet” installations above, using an elbow.

Canopy Inlets: The slope of the barrel, whether CMP or PVC, shall not exceed that shown on the Nebraska Standard Drawings (See Engineering Field Manual, Appendix 2). The grade of the outlet section shall be limited as for “drop inlet” installations above, except that PVC conduits shall use standard elbows with maximum outlet slope not to exceed 5 percent.

10. Water Supply Lines

For design of supply pipes through the dam for the purpose of irrigation, livestock water, fire protection, etc.; refer to the applicable standard in Section IV of the Field Office Technical Guide (FOTG).

Auxiliary Spillways

1. General

Auxiliary spillways are provided to convey large flood flows safely past earth embankments to a point downstream where the dam will not be endangered.

An auxiliary spillway must be provided for each dam unless the principal spillway is large enough to pass the routed design hydrograph peak discharge without overtopping the dam. The principal spillway must also be large enough to pass the trash that comes to it without plugging.

A closed-conduit principal spillway, having a conduit with a cross-sectional area of 3 square feet (24 inch diameter) or more, an inlet which will not clog, and an elbow designed to facilitate the passage of trash, is the minimum size and design that may be utilized without an auxiliary spillway.

For auxiliary spillway design requirements, refer to the Nebraska supplement entitled “Emergency and Principal Spillway Proportioning Guide” found in chapter 2 of the Engineering Field Manual.

2. Capacity

   a. Structures with an effective height less than 20 ft and storage below the auxiliary spillway crest of less than 50 ac ft: Minimum capacity shall pass the peak flow from a 25-year, 24-hour design storm.

   b. Structures either larger than 20 ft effective height or more than 50 ac ft total storage: Minimum capacity shall pass the peak flow from a 50-year, 24-hour storm.

3. Reservoir Routing

   a. Flow through the auxiliary spillways shall be determined by accepted reservoir routing procecures.

      The routing shall start with the water surface at the elevation of the crest of the principal spillway or at the water surface after 10 days’ drawdown, whichever is higher.

      The 10-day drawdown shall be computed from the crest of the auxiliary spillway or from the elevation that would be attained had the entire design storm; been impounded, whichever is lower. In no case shall the auxiliary spillway width be less than 12 ft.

   b. Storage and Discharge

      The design flow through the auxiliary spillway may be reduced due to the combined effects of principal spillway discharge and available detention storage at the site.

   c. Depth of Flow

      The final design flow depth (Hp) shall not exceed the assumed depth in the chart for the spillway level section used in accordance with the “Proportioning Guide” (see Nebraska supplements) in chapter 2 of the Engineering Field Manual.

   d. Velocity

      Auxiliary spillways shall be designed for safe velocities through the exit channel. The exit channels shall extend downstream past the toe of the dam.

Allowable velocities and classification of retardance shall be in accordance with exhibit 11-2 in Chapter 11 of the Engineering Field Manual.

Selected design velocities and estimated flow rates will determine the design widths and exit slopes. These widths and slopes must be evaluated against actual site conditions and the most appropriate combination selected.

4. Physical Layout

   a. Side Slopes

   Unless constructed in rock, the side slopes should generally not be steeper than 2:1. In unusual situations where spillway cuts exceed 15 feet, and where soils are stable, the side slopes may be 1 ½:1. In loess soils, where the base of the slope is protected by a berm, side slopes of ¼:1 may be used. Protective measures as necessary shall be used to prevent erosion on slopes and for safety of livestock.

   b. Profile

   Upstream from the control section, the inlet channel shall be level for the distance needed to protect and maintain the crest elevation of the spillway. The minimum length of level section is 25 feet. The slope of a constructed approach channel shall not exceed 3 percent and shall slope downward toward the reservoir from the upstream edge of the level section.

   c. Alignment

   Any curvature in the auxiliary spillway should be upstream from the level section. However, when long level sections are needed for auxiliary spillway stability, only 25 feet upstream from the control section needs to be in straight alignment with the outlet. The spillway channel downstream from the control section should be straight. When it is necessary that curvature be used downstream from the control section, it should be far enough downstream that the flow will not come in contact with the back slope of the embankment.

   A wing dike shall be provided if needed to prevent the spillway flow from coming in contact with back slope of dam. The top elevation of the dike along the level section of the spillway shall be the same as the design height of the dam. Below the outlet of the control section, the top of the dike, height shall be equal to or greater than the maximum depth of the water in the spillway at peak flood flow.

BENEFICIAL STORAGE

Livestock Water

The required storage will be calculated using 1.5 times the sum of the following criteria: (1) the specified gallons per animal unit per day, from NRCS Standard 516, for the estimated number of days to be used, (2) the net evaporation loss (see Nebraska supplement entitled “Nebraska Net Evaporation from Ponds and Reservoirs” in Chapter 2 of the Engineering Field Manual), and (3) seepage based upon the best available local records.

Additional storage will be provided to handle the estimated volume of silt that will be deposited in the reservoir during the life of the structure. (To estimate silt storage , see Nebraska supplement entitled “Computing Erosion and Sediment Storage Requirements for Small Structure” in Engineering Field Manual, Chapter 2.

Fish

Design the reservoir for a maximum amount of water in excess of 3 feet in depth. At the time of construction, as much of the shoreline as possible, excluding the structure, shall have slopes of 3:1 or steeper to a minimum depth of 3 feet to facilitate control of aquatic weeds. (See FOTG, NRCS Standard 399, “Fishpond Management” for additional information and requirements on ponds for fish).

An area 40 feet or more in width, immediately adjacent to the permanent waterline of the pond, should be grass and maintained as permanent vegetative cover.

Fire Protection Using Dry Hydrants

Fire protection may be incorporated into a structure design by incorporating an underground piping system which connects the reservoir to a dry hydrant (or standpipe).

The dry hydrant must be located near an all-weather road and must be marked so that it is easily identified. It must be fitted with a standpipe connection compatible with the hose connections used by the local Fire Department.

The underground piping system must be designed so that it can deliver a minimum of 250 gallons per minute and must also be protected from freezing.

The intake in the pond must be deep enough to deliver an adequate supply of water during periods of drought. If the pond is used for other purposes, such as irrigation or livestock watering, these consumptive uses must be accounted for when designing the intake.

The intake must be equipped with a strainer and be at least 2 ft above the pond bottom to provide protection from sediment. A dry hydrant system should not be installed unless the permanent pond level can be maintained at least 7 feet above the intake, providing an allowance for summer evaporation and winter ice.

For guidance on Dry Hydrant design see National Planning Procedures Handbook, Section NE600.7-37, NE Exhibit 66.

Visual Resource Design

Ponds in areas of high public visibility and those associated with recreation are to receive careful visual design. The underlying criterion for all visual design is appropriateness. The shape and form of ponds, excavated material, and plantings are to relate visually to their surroundings and to their function.

The embankment may be shaped to blend with the natural topography. The edge of the pond may be shaped so it is generally curvilinear rather than rectangular. Excavated material may be shaped so the final form is smooth, flowing, and fitting to the adjacent landscape rather than angular, geometric mounds. Where feasible, islands may be added for visual interest and wildlife value.

EXCAVATED PONDS

Design Criteria

Runoff

Provisions should be made for a pipe and auxiliary spillway where necessary. Runoff flow patterns are to be considered when locating the pit and placing the spoil . (See Nebraska supplement entitled “Emergency and Principal Spillway Proportioning Guide” in Chapter 2 of the Engineering Field Manual).

Side Slopes

Side slopes of excavated ponds shall be such that they will be stable and shall not be steeper than 1 horizontal to 1 vertical. In cases where there may be rapid drawdown, the side slopes shall not be steeper than 2:1. Where surface water enters the pond in a natural or excavated channel, the side slope of the pond shall be protected against erosion. Where livestock will water directly from the pond, a watering ramp of ample width shall be provided. The ramp shall extend to the anticipated low water elevation at a slope no steeper than 4 horizontal to 1 vertical.

Perimeter Form

Where the structures are used for recreation or are located in high public view, the perimeter or edge should be shaped to a curvilinear form.

Placement of Excavated Material

The material excavated from the pond shall be placed in one of the following ways so that its weight will not endanger the stability of the pond side slopes and it will not be washed back into the pond by rainfall:

- Uniformly spread to a height not exceeding 3 feet with the top graded to a continuous slope away from the pond.
- Uniformly placed or shaped reasonably well with side slopes assuming a natural angle of repose for the excavated material behind a berm width equal to the depth of the pond but not less than 12 feet.

- Shaped to a designed form that blends visually with the landscape.
- Used for low embankment and leveling.
- Hauled away.

Revegetation

All of the embankment, auxiliary spillway, spoil bank or other disturbed areas caused by construction shall be vegetated as part of each job.

PLANS AND SPECIFICATIONS

Plans and specifications for installation of ponds shall be in keeping with this standard and shall describe the requirements for constructing and vegetating this practice.

Preparation of Construction drawings and specifications will follow procedures in the Engineering Field Manual, chapter 5, “Preparation of Engineering Plans”.

Construction and material specifications used for Ponds will be either the Nebraska PL-46 specifications or the “NE” series specifications found in Appendix 1 of the Engineering Field Manual.

The specifications for revegetating the embankment and auxiliary spillway areas shall be developed in accordance with the requirements for “CRITICAL AREA PLANTING” and “Mulching” NRCS Standards 342 and 484.

OPERATION AND MAINTENANCE

A comprehensive maintenance plan, carried out by the owner will enhance the useful life of the pond. The owner or other responsible persons must be advised of their responsibilities and be counseled as to timing of maintenance inspections and methods of performing maintenance.

See pages M-378-1 and 2 for an example O & M plan. For most ponds this example will suffice for the O & M plan. When necessary it can be modified to fit individual site conditions.

REFERENCES

NEBRASKA FIELD OFFICE TECHNICAL GUIDE (FOTG),

SECTION IV, PRACTICE STANDARDS & SPECIFICATIONS

- 342 Critical Area Treatment
- 399 Fishpond Management
- 410 Grade Stabilization Structure
- 430 Pipeline, irrigation
- 516 pipeline, livestock

ENGINEERING FIELD MANUAL (including Nebraska supplements)

- EFM Appendix 1, Nebraska Construction Specifications
- EFM Appendix 2, Nebraska Standard Drawings
- EFM Chapt 2, Hydrology
- EFM Chapt 3, Hydraulics
- EFM Chapt 4, Elementary Soils Engineering
- EFM Chapt 5, Preparation of Engineering Plans
- EFM Chapt 6, Structures
- EFM Chapt 7, Grassed Waterways & Outlets
- EFM Chapt 11, Ponds and Reservoirs
- EFM Chapt 13, Wetland Restoration
- EFM Chapt 17, Construction & Construction Materials

NATIONAL ENGINEERING HANDBOOK

- SECTION 3, Sedimentation (Chapt 3, Erosion), (Chapt 6, Sources, Yields, Delivery Ratios), (Chapt 8, Storage Design Criteria)
- SECTION 8, Engineering Geology (Chapt 5, Classification of Structure Sites)

TECHNICAL RELEASES

- TR-56, Wave Protection For Earth Dam Embankment
- TR-69, Riprap For Slope Protection Against Wave Action
- TR-77, Design & Installation of Flexible Conduits

NEBRASKA PLANNING PROCEDURES HANDBOOK

- SECTION NE607-37, Exhibit NE 66, Form NE-ENG-75 & 76, Layout and Design of a Dry Hydrant
- Nebraska PL-46 Construction and Material Specifications
- Nebraska NE-Construction Specifications

NEBRASKA GUIDES

- Guide to Nebraska Wave Protection Criteria (Design Section)

NEBRASKA ENGINEERING COMPUTER PROGRAM HANDBOOK

- User Manuals & Other Information About Computer Programs Used For Design Of Engineering Practices In Nebraska

EMERGENCY AND PRINCIPAL SPILLWAY PROPORTIONING GUIDE

NUMERICAL RATING	SPILLWAY FLOW DEPTH (Hp)	MAXIMUM SPILLWAY GRADES		CONDITION AT RE-ENTRANCE TO MAIN CHANNEL	VEGETATIVE COVER (Existing or Potential)	PROTECTION
		EASILY ERODED [1]	RESISTS EROSION [2]			
5	1.0' 1.5' 2.0' 2.5'	5% 2%	8% 5% 3% 2%	No "Drop Off" 300' below control section (c.s.) No concentration.	Very good stand of sod-forming grasses.	Area fenced or no live- stock.
4	1.0' 1.5' 2.0'	6% 3%	10% 6% 4%	"Drop Off" less than 3', 250' + below c.s.--No concentration,	Good stand or high potential for good stand.	Cropland adjacent - Not fenced.
3	1.0' 1.5'	7% 4%	12% 7%	"Drop Off" 3'-7', 150' + below c.s.--Shrubby banks—Slight concentration.	Medium stand or good potential for medium stand.	In pasture - Not fenced.
2	1.0' 1.5'	8% 5%	14% 8%	"Drop Off" 3'-7', 150' + below c.s.--Moderate concentration,	Fair stand or good potential for fair stand.	Dam and spillway used for crossing.
1	1.0' 1.5'	9% 8%	16% 9%	"Drop Off" 7'+, 150'+ below c.s.-- Slight concentration,	Poor stand or lacks potential for good stand.	Within farmstead area - Not fenced.

SPILLWAY CLASS RATING		EMERGENCY SPILLWAY	PRINCIPAL SPILLWAY MINIMUM DESIGN REQUIREMENTS	
ADJECTIVE	NUMERICAL	PERMISSIBLE FREQUENCY OF SPILLWAY OPERATION See foot note 4	Without Storage-Pipe Capacity, % of 25yr.-24hr. Peak [3]	With Storage-Storm Frequency To Be Routed Below Emergency Spillway
Excellent	20-18		May be designed without principal spillway.	
Very Good	17-15	1-2 times per year	25	2 yr. - 24 hr.
Good	14-12	Once per year	35	2 yr. - 24 hr.
Fair	11-9	Once in 4 years	50	5 yr. - 24 hr.
Poor	8-6	Once in 8 years	75	10 yr. - 24 hr.
Very Poor	5-4	Once in 25 years	100 [5]	25 yr. - 24 hr.

[1] Easily eroded soil has a P.I. less than 10 or greater than 40.
[2] Soil that resists erosion has a P.I. between 10 and 40.
[3] Minimum combined capacity of the principal & emergency spillways must safely pass the peak flows of the 24-hour storm as shown in the appropriate standard.
[4] Indeterminate-Dependant upon storm frequency and net evaporation.
[5] For extreme spillway conditions, consideration may need to be given to providing for a principal spillway capacity in excess of the 25-year peak flow.

EXAMPLE:

Spillway Grade (Hp = 1.5', easily eroded soil)- 4%	3
Channel Re-Entrance - 1'"Drop Off" - 500' below c.s	5
Vegetative Cover - Medium	3
Protection - In pasture -Not fenced	3
NUMERICAL RATING:	14
ADJECTIVE RATING:	Good

Criteria are somewhat flexible. EXAMPLE: "Condition at re-entrance to main channel." (a) "Drop Off" is 4.6 ft.-Shrubby cover (Less than mid-point of permissible height for a "3" numerical rating) (b) "Drop Off" is 215 ft. below control section. (Greater than mid-point between the "3" and "4" numerical ratings) CONCLUSION: Rating may be advanced (raised) one step to "4". Same principle may be applied to other combinations such as "shrubby cover", "concentration", etc., in "raising" or "lowering" ratings. The grading of drop offs at a time of construction may be considered providing the potential for establishment of sod cover is adequate. "1 is the minimum numerical rating to be used for any element.

RATING OF EMERGENCY SPILLWAYS BELOW

(a) Control Section

This chart is intended to be used as a guide with some flexibility.

In addition to the example shown at the bottom of the table, judgment should be used in the application of a rating under each of the headings. Consideration might well be given to "grading out" the drop-off at re-entrance, plus backfilling with good topsoil and seeding to eliminate the "drop-off" hazard.

Combination of spillway flow depths and spillway grades will require some interpolation for soils ranging between those that are easily eroded and those that are erosion resistant. Generally, erosion resistant soils are heavy clays or silty clays with strong structure; moderately erosive soils are silt loamy to silty clay loams with a medium structure and easily eroded soils are light loamy sands and loamy silts with weak structure.

Seepage losses from a reservoir site may be an additional factor to those shown in the spillway classification chart and may be used in determining the need and/or size of the principal spillway. Example: Where the seepage from the reservoir over a ten-day period is equal to or exceeds the total inflow from a 2-year storm, a dam may be designed without a principal spillway even though the emergency spillway rates only as "good" (12-14 numerically).

The best criteria for determining the rate of seepage loss from reservoirs is based on local experience where observations have shown that sites on certain soil formations under certain conditions lose water at a known rate. Where silting of the reservoir will be by fine-grained soils that will tend to seal the reservoir and cause the seepage losses to become ineffective, such effects must be evaluated and reflected in the design of the structure.