United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

POND

CODE 378

(no)

DEFINITION

A water impoundment made by constructing an embankment, excavating a dugout, or a combination of both.

In this standard, NRCS defines ponds constructed by the first method as embankment ponds and those constructed by the second method as excavated ponds. Ponds constructed using a combination of the excavation and embankment methods are classified as embankment ponds if the depth of water impounded against the embankment at the auxiliary spillway elevation is 3 feet or more above the lowest original ground along the centerline of the embankment.

PURPOSE

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

- Store water for:
  - Livestock
  - Fish and wildlife
  - Recreational use
  - Fire control
  - Erosion control
  - Flow detention
  - Improve water quality

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all excavated ponds. It also applies to embankment ponds that meet all criteria for low-hazard potential dams as listed below **and described in NEM 520.21**:

- The failure of the dam will not result in loss of life, damage to homes, commercial or industrial buildings, main highways, or railroads, or in interruption of the use or service of public utilities. **Damage to structures and roads include any inundated or**

overtopping resulting from a dam breach. For assistance with a dam breach model consult with the State Conservation Engineer.

- The product of the storage times the effective height of the dam is less than 3,000 acre-feet[2]. Storage is the capacity of the reservoir in acre-feet below the elevation of the crest of the lowest auxiliary spillway or the elevation of the top of the dam if there is no open channel auxiliary spillway. The effective height of the dam is the difference in elevation, in feet, between the lowest open channel auxiliary spillway crest and the lowest point in the original cross section taken on the centerline of the dam. If there is no open channel auxiliary spillway, use the lowest point on the top of the dam instead of the lowest open channel auxiliary spillway crest.
- The effective height of the dam is 35 feet or less.

CRITERIA

General Criteria Applicable to All Ponds

All necessary local, state, and federal permits shall be obtained by the producer or their designee. Construction specifications and/or drawings will specify that NRCS be provided copies of all required permits prior to construction. Excavation or embankment work within or near streams and wetlands may require a permit from the U.S. Army Corps of Engineers in accordance with Section 404 of the Clean Water Act (Bismarck Regulatory Office). Projects that disturb more than 1 acre are required to develop a Stormwater Pollution Prevention Plan and submit it along with a Notice of Intent to the ND Department of Environmental Quality (DEQ). Projects within the ordinary high-water mark of navigable lakes and streams require a Sovereign Lands Permit from the ND Department of Water Resources.

In addressing the National Environmental Policy Act (NEPA) for conservation practices within or near wetlands, sequencing must be conducted as per Executive Order 11990 included in Section
G. Wetlands of the NRCS-CPA-052. Sequencing must include avoiding impacts if feasible, including those from altered hydrology to wetlands. If avoidance is not feasible, a determination will be made using the North Dakota Minimal Effect Evaluation Worksheet. If the effects are determined to be minimal, the determination will be included in the NRCS-CPA-052. If the determination is not minimal, either wetland mitigation credits must be purchased from an approved mitigation bank or completed on site, on the basis of an HGM evaluation of lost wetland function. Implementation of the conservation practice(s) impacting the wetland(s) may begin upon obtaining either the letter of approved sale from the mitigation bank or all signatures on the wetland mitigation plan and agreement.

Ponds utilized in conjunction with grazing systems must: (1) alter grazing patterns to enhance water quality, protect critical areas, and improve the distribution of grazing, (2) protect reliable water quality and quantity to meet livestock requirements, and (3) be a practical method of providing the needed water. Normal distribution of water facilities provides water between ¼ to ½ mile distance in rough terrain, and ½ to 1 mile in gentle terrain. For more specific guidelines, refer to the National Range and Pasture Handbook.

Wildlife developments must provide a suitable environment for the wildlife for which it is to be constructed. For management criteria and site information, see CPS Code 644, Wildlife Wetland Habitat Management.

Plan, design, and construct the pond to comply with all Federal, State, and local laws and regulations. Notify landowners and/or 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.

Design a minimum sediment storage capacity equal to the design life of the structure, or provide for periodic cleanout. Protect the drainage area above the pond to prevent sedimentation from adversely affecting the design life.

Design measures necessary to prevent serious injury or loss of life according to the requirements of NRCS National Engineering Manual (NEM) (Title 210), Part 503, “Safety.”

Seed or sod the exposed surfaces of earthen embankments, earth spillways, borrow areas, and other areas disturbed during construction in accordance with the criteria in NRCS Conservation Practice Standard (CPS) Critical Area Planting (Code 342). When necessary to provide surface protection where climatic conditions preclude the use of seed or sod, use the criteria in NRCS CPS Mulching (Code 484) to install inorganic cover material such as gravel.

Cultural resources
Evaluate the existence of cultural resources in the project area and any project impacts on such resources. Provide conservation and stabilization of archeological, historic, structural, and traditional cultural properties when appropriate.

Site conditions
Select or modify the site to allow runoff from the design storm to safely pass through a natural or constructed auxiliary spillway, a combination of a principal spillway and an auxiliary spillway, or a principal spillway.

Select a site that has an adequate supply of water for the intended purpose through surface runoff, ground water, or a supplemental water source. **Planning work for ponds should be completed following guidance within NRCS Agricultural Handbook 590.** Water quality must be suitable for its intended use. **If water quality issues are anticipated based on local conditions, ensure O&M Plan provides long term testing recommendations.**

Reservoir
Provide adequate storage volume to meet user demands for all intended purposes. Account for sedimentation, season of use, evaporation loss, and seepage loss when computing the storage volume.

Additional Criteria for Embankment Ponds

Follow North Dakota Century Code Section 61-04-02 requirement that structures with a water storage capacity (spillway elevation) exceeding 12.5 acre-feet to secure a water permit from the ND DWR prior to construction or modification activities. The DWR Water Appropriates Division oversees Applications for Conditional Water Permits (SFN 60157). In these instances, construction specifications developed for the project should specify that NRCS be provided a copy of the water permit prior to construction.

Follow North Dakota Century Code Section 61-04-02 requirement that structures with a water storage capacity (spillway elevation) less than 12.5 acre-feet to notify the state engineer (DWR) of the location and capacity of such constructed works, dams, or dugouts. DWR oversees notifications of embankment constructions (SFN 51695). In these instances, construction specifications developed for the project should specify that NRCS be provided a copy of the notification prior to construction. Follow North

Dakota Century Code Section 61-16.1-38 requirement that applications for embankments with height 10 feet or greater to include complete plans and specifications stamped by a professional engineer registered in the state.

Constructed embankment ponds that meet any of the following criteria must be included in the national inventory of NRCS-assisted dams in accordance with the NEM, Section 520.21(F)- request assistance from the ND State Conservation Engineer in these instances:

1. **Equal or exceed 25 feet in effective height and exceed 15 acre-feet in storage**
2. **Equal or exceed 50 acre-feet storage and exceed 6 feet in effective height.**

The ND DWR will determine dam hazard classification under their criteria when the applicant applies for a construction permit. Per NEM, Section 520.23, NRCS will determine hazard classification at the time of inventory and evaluation work (planning), and then verify that classification immediately prior to construction. The design engineer, or approving engineer, having appropriate engineering job approval authority is responsible for the classification. Only those dams that meet the NEM criteria for a low hazard dam may be designed under ND NRCS CPS 378.

Geological investigations

Use pits, trenches, borings, and reviews of existing data or other suitable means of investigation to characterize materials within the embankment foundation, auxiliary spillway, and borrow areas. Classify soil materials using ASTM D2487-17e1, “Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).” Determine from the investigations if problem soils exist at the embankment pond site for defensive design measures. Problem soils, include but are not limited to dispersive clays, collapsible soils, soft clays, expansive clays, low internal erosion resistance soils, loose coarse-grained soils, high soluble content soils, and caliche soils.

Complete an earth boring (ND-ENG-41) for the site to determine, at minimum, identification with unified soil classification system and the seasonal high-water table for the potential to hold the planned quantity of water. Locate overhead and buried utilities at site. Complete North Dakota ONE CALL for subsurface excavations or borings and record on ND-ENG-2.

Conduct investigations in accordance with procedures in NEH, Part 631, Chapter 2, Engineering Geology Investigations, and policy in NEM Part 531, Subpart A, Geologic Investigations. Complete indicator tests to identify dispersive clays (Crumb test) in all embankment dams with clay (CH or CL) borrow. The indicator shall be completed prior to the final design preparation. Log subsurface investigations for all ponds sufficient in detail and analysis to support the design in accordance with NEM Part 531, Subpart B – Engineering Geology. Document the location of test pits or soil borings, soil test results, photos taken during the soils investigation, and a narrative describing the design parameters that have been derived from the soils data. Drill or excavate at least two boreholes within the lateral boundaries of the proposed structure or excavated pond. Extend these test pits/soil borings to bedrock, a free water surface, or to a minimum depth of 10-feet below the proposed bottom of the pond. A geological report shall be completed in accordance with NEM Part 531, Subpart A, Section 531.4. For sites where geologic conditions are complex or unstable, an NRCS Geologist shall conduct or supervise the geologic investigation. Contact the State Conservation Engineer to schedule a site investigation by a NRCS Geologist for embankment dams in excess of 20 feet in effective height.

Foundation cutoff
Design a cutoff of relatively impervious material under the dam and up the abutments as required for preventing seepage. Locate the cutoff at, or upstream from, the centerline of the dam. Extend the cutoff deep enough to intercept flow and connect with a relatively impervious layer. Combine seepage control with the cutoff as needed. Use a cutoff bottom width adequate to accommodate the equipment used for excavation, backfill, and compaction operations. **The cutoff shall be deepened and widened as necessary to remove all stones, gravel, sand stumps, roots, and other objectionable material.** Design cutoff side slopes no steeper than one horizontal to one vertical. **The entire embankment foundation, including cutoff, should be cleared of trees, logs, stumps, roots, brush, boulders, sod, and rubbish. The foundation area shall be thoroughly scarified before placement of the fill material. The surface shall have moisture added, if necessary, and shall be compacted so that the first layer of fill material can be compacted and bonded to the foundation.**

Seepage control
Include seepage control if—

- Foundation cutoff does not intercept pervious layers.
- Seepage could create undesired wet areas.
- Embankment stability requires seepage control.
- Special problems require drainage for a stable dam.

Filter zones may be required in some embankment designs to address the problem of cracking and internal erosion of the embankment for sites with problematic conditions such as dispersive clays, steep abutments, and other issues.

Control seepage with—

- Foundation, abutment, or embankment filters and drains.
- Filter diaphragms.
- Reservoir bottom blanketing.
- A combination of these measures.

All conduits, through or under earth embankments, foundations and abutments, shall be protected with anti-seep collars or drainage diaphragms. This includes pipelines, utility lines, trickle tube, etc.

Top width
Table 1 provides the minimum top widths for dams of various total heights. Total height is the vertical distance between the settled top of the dam and the lowest elevation at the downstream toe.

Design a minimum width of 16 feet for one-way traffic and 26 feet for two-way traffic for the top of a dam used as a public road. Design guardrails or other safety measures where necessary and follow the requirements of the responsible road authority. For dams less than 20 feet in total height, maintenance considerations or construction equipment limitations may require increased top widths from the minimum shown in table 1.

Table 1. Minimum Top Width for a Dam.

Total Height of Dam (feet)	Top Width (feet)
Less than 19.9	**10**
20–24.9	12
25–35	15

Side slopes
Design **upstream** side slope with a ratio of**three** horizontal to one vertical or flatter. Design the sum of the upstream and downstream side slopes with a ratio of five horizontal to one vertical or flatter. As required, design benches or flatten side slopes to assure stability of all slopes for all loading conditions. Flatter slopes may be required for stability for some problematic embankment or foundation soils such as highly plastic embankment soils or very soft clays. Downstream or upstream berms can be used to help achieve stable embankment slopes.

Slope protection
Design special measures such as berms, riprap, sand-gravel, soil cement, or use special vegetation as needed to protect the slopes of the dam from erosion. Use NRCS Engineering Technical Release (TR) 210-56, "A Guide for Design and Layout of Vegetative Wave Protection for Earth Dam Embankments," and TR-210-69, "Riprap for Slope Protection against Wave Action," as applicable. **Slope protection for small embankment ponds may be determined from table 2. Direct fetch is the longest uninterrupted distance across the water directed at the embankment.**

Table 2. Slope protection for small embankment ponds.

Direct Fetch *(feet)*	**Slope Protection**
0 - 499	**Vegetation with routine maintenance**
500 – 1,800	**Vegetated 10' wide berm at permanent pool elevation with minimum 4:1 upstream slope below berm**

Slope Stability

Slopes that are part of earthen embankment structures, used in the temporary to long-term impoundment or temporary to long-term relay of water, are to be assessed for slope stability. Slopes that are part of embankments that are less then 8'-0" in height and have side slopes flatter than 3:1 (horizontal: vertical), do not need to be assessed for slope stability. Design and assessment requirements for slope stability detailed in this practice standard only pertain to earthen embankment slopes having a total height of 20'-0" or less.

Existing slopes having an addition of earthen fill atop, for purposes of the practice, shall be assessed for slope stability regardless of the height of the new portion of the embankment or slope. The slope stability assessment is to be conducted upon the entire complete slope height and side slope extents.

Geological investigations should document existing soil as well as the requirement for scarification of existing soil surfaces so as to create an adequate interface between the new and existing soil materials, for consideration of slope stability.

1. **Steady-State (Steady-Seepage) scenario: Incorporate a phreatic surface which begins at the water surface elevation of the water impounded side of the embankment and extends through the embankment to the toe or expected tail water surface elevation, whichever is higher. The critical results for this scenario must have a factor of safety for slope stability greater than 1.4.**
2. **Flood Surcharge scenario: Incorporate a phreatic surface which may be higher than the phreatic surface estimated for the steady-state condition, resulting from the addition of short-term seepage from the temporary higher water surface elevation. In order to determine the phreatic surface change caused by a flood surcharge, a permeability study of the new fill material or existing native soil shall be conducted. Alternatively, a conservative approach would be to assume that the phreatic surface begins at the flood surcharge water surface elevation. The critical results for this scenario must have a factor of safety for slope stability greater than 1.3.**
3. **Rapid Drawdown scenario: Incorporate a phreatic surface which, at a minimum, mimics the Steady-State condition. The rapid drawdown scenario may be assessed as well, for the Flood-Surcharge scenario, having the starting water surface elevation as the embankment height and the water surface elevation for the Steady-State scenario as the ending water surface elevation. The critical results for this scenario must have a factor of safety for slope stability greater than 1.2.**

Freeboard
Design a minimum of 1 foot of freeboard between design high-water flow elevation in the auxiliary spillway and the top of the settled embankment. Design a minimum 2 feet of elevation difference between the crest of the auxiliary spillway and the top of the settled embankment when the dam has more than 20 acre drainage area or more than 20 feet in effective height. Design a minimum of 1 foot of freeboard above the peak elevation of the design hydrograph to the top of the settled embankment when the pond has no auxiliary spillway.

Settlement
Increase the height of the dam by the amount needed to ensure that the settled top elevation of the dam equals or exceeds the design top elevation. Design a minimum settlement allowance of 5 percent of the total height of the dam associated with each dam cross section, except where detailed laboratory soil testing and settlement analyses or experience in the area shows that a lesser amount is adequate. **Project design drawings and/or specifications should clearly outline requirements to strip the borrow area to remove all vegetation and material undesirable for fill and stockpile (if appropriate) to be used later for cover over the dam, spillway, or borrow area as needed for vegetation re-establishment.**

Principal spillway
A pipe with needed appurtenances shall be placed under or through the dam, except where rock, concrete, or other types of lined spillways are used, or where a vegetated or earth spillway can safely handle the rate and duration of the design flow.

Design a minimum of 6-inches difference between the crest elevation of the auxiliary spillway and the crest elevation of the principal spillway when the dam has a drainage area of 20 acres or less. Design a minimum of 1 foot difference when the dam has a drainage area of over 20 acres.

Provide an anti-vortex device to handle pressure flow in the principal spillway pipe. Design the inlet and outlet to function for the full range of flow and hydraulic head anticipated.

Design adequate pipe capacity to discharge long-duration, continuous, or frequent flows without causing flow through the auxiliary spillway. **The minimum capacity of the principle spillway shall be the routed flow from a 2 year-24 hour storm without flow through the auxiliary spillway, as determined by SITES, HEC-RAS, or TR20 analysis. When the project is classified as a Detention storage may be considered in the design of the principle spillway, which can be considered in an unsteady hydraulic analysis** Design a principal spillway pipe with a minimum inside diameter of **6** inches. **If principle spillway capacity is not required for routing; a trickle tube shall still be installed as principle spillway, with minimum inside diameter of 4 inches, to reduce persistent auxiliary spillway flows.** Design pipe with a minimum inside diameter of 1-1/4 inches for water supply pipes or for pipes used for any other purpose.

Design pipe using ductile iron, welded steel, corrugated steel, corrugated aluminum, reinforced concrete (precast or site-cast), or plastic. Do not use cast iron or unreinforced concrete pipe if the dam is 20 feet or greater in total height.

Design and install pipe to withstand all external and internal loads without yielding, buckling, or cracking. Design rigid pipe for a positive projecting condition. Design flexible pipe according to the requirements of NRCS National Engineering Handbook (NEH) (Title 210), Part 636, Chapter 52, “Structural Design of Flexible Conduits.”

Design connections of flexible pipe to rigid pipe or other structures to accommodate differential movements and stress concentrations. Design and install all pipes to be watertight using couplings, gaskets, caulking, water stops, or welding. Design joints to remain watertight under all internal and external loading, including pipe elongation due to foundation settlement.

Design a concrete cradle or bedding for pipe if needed to reduce or limit structural loading on the pipe and improve support of the pipe.

Design outlet structures, such as cantilever pipe outlet sections**, stilling basin**, and impact basins, to dissipate energy as needed. **Refer to FEMA P-679 for design guidance. Cantilever pipe outlet sections shall be designed to withstand full pipe cantilever load, plus applicable external loads such as ice buildup. Pipe supports shall be provided when needed. A pipe support shall be used for cantilevered outlet of 24 inch diameter or larger conduits. The pipe support shall be placed at the intersection of the downstream slope of the embankment and the flow line of the outlet channel. A structural analysis shall be completed for cantilever pipe supports and foundation using appropriate design references. The cantilever length shall extend a minimum of 5 feet beyond the pipe support and shall be a minimum of 2 feet above the outlet channel for supported pipes and a minimum of 1 foot above the outlet channel when not supported. The minimum length of a cantilever outlet section shall be 20 feet (without a joint) to provide adequate cover and support strength. Concrete rubble shall not be used as a substitute for rock riprap within plunge pools.**

Corrosion protection
Provide protective coatings for all steel pipe and couplings in areas that have traditionally experienced pipe corrosion or in embankments with saturated soil resistivity less than 4,000

ohm-cm or soil pH less than 5. Protective coatings may include asphalt, polymer over galvanizing, aluminized coating, or coal tar enamel.

Ultraviolet protection
Use ultraviolet-resistant materials for all plastic pipe or provide coating or shielding to protect plastic pipe exposed to direct sunlight.

Cathodic protection
Provide cathodic protection for coated welded steel and galvanized corrugated metal pipe where soil and resistivity studies indicate that the pipe needs a protective coating and where the need and importance of the structure warrant additional protection and longevity. **Cathodic protection should be provided for corrugated steel pipe where the saturated soil resistivity is less than 2,500 Ohm-cm, and shall be provided if less than 1,500 Ohms-cm.** If the original design and installation did not include cathodic protection, consider establishing electrical continuity in the form of joint-bridging straps on pipes that have protective coatings. Add cathodic protection later if monitoring indicates the need.

Internal erosion
Install filter diaphragms for internal erosion control or anti-seep collars to reduce hydraulic gradient along the pipe extending through the embankment with inverts below the peak elevation of the routed hydrograph when the effective height of the dam is 15 feet or greater.

Filter diaphragms
Design the filter diaphragm according to the requirements of 210-NEH, Part 628, Chapter 45, “Filter Diaphragms.” Locate the filter diaphragm immediately downstream of the cutoff trench, but downstream of the centerline of the dam if the foundation cutoff is upstream of the centerline or if there is no cutoff trench.

To improve filter diaphragm performance, provide a drain outlet for the filter diaphragm at the downstream toe of the embankment. Protect the outlet from surface erosion and animal intrusion.

Ensure that the filter diaphragm functions both as a filter for adjacent base soils and as a drain to intercept seepage. Materials for the filter diaphragm must meet the requirements of 210-NEH-Part 633, Chapter 26, “Gradation Design of Sand and Gravel Filters”. **The filter drainage diaphragm dimensions shall be designed under the methods outlined in NEH Part 628, Chapter 45, Appendix A.**

Anti-seep collars can be used where the following soil and site conditions apply:

- Embankment soils are documented to be non-dispersive by crumb testing or evidence that the site is located in geologic formations that are known to be non-dispersive.
- Soils tests show that embankment soils have a plasticity index (PI) equal to or greater than 15.
- The water content of the soils at the time of construction is such that a 1/8-inch diameter thread 1/2- inch long may be rolled out on a flat surface without breaking or falling apart.
- Natural or excavated ground slopes transverse to the embankment centerline in the vicinity of the conduit are no steeper than 2 horizontal to 1 vertical.
- Laboratory or field tests show that the foundation soils left in-place under the embankment and principal spillway are medium to very stiff in saturated consistency or medium dense to very dense depending on if these soils are cohesive or cohesionless, respectively.

When using anti-seep collars in lieu of a filter diaphragm, ensure a watertight connection to the pipe. Limit the maximum spacing of the anti-seep collars to 14 times the minimum projection of the collar measured perpendicular to the pipe, or 25 feet, whichever is less. Locate anti-seep collars no closer than 10 feet apart. Use a collar material that is compatible with the pipe material.

Design the collars to increase the seepage path along the pipe within the fill by at least 15 percent.

Trash guard
Install a trash guard at the riser inlet to prevent clogging of the pipe, unless the watershed does not contain trash or debris that could clog the pipe.

Pool drain
Provide a pipe with a suitable valve to drain the pool area if needed for proper pond management or if required by State law. The designer may use the principal spillway pipe as a pond drain if it is located where it can perform this function.

Auxiliary spillways
A dam must have an open channel auxiliary spillway, unless the principal spillway is large enough to pass the peak discharge from the design hydrograph and the trash that comes to it without overtopping the dam. The minimum criteria for acceptable use of a closed pipe principal spillway without an auxiliary spillway consists of a pipe with a cross-sectional area of 3 square feet or more, an inlet that will not clog, and an elbow designed to facilitate the passage of trash.

The only exception to Table 3 guidance would be when a gauge with at least 10 years of peak flow records exists near to the project site and the ratio of the project drainage area to the gauge drainage area falls within 50% and 150%. In that case, USGS Scientific Investigations Report 2015-5096 Equation 4 should be used in combination with a Log-Pearson Type III analysis of up-to- date gauge records to determine peak flows for the gauge (contact State Hydrologist for assistance). Note that gauge peak flow statistics in Stream Stats are listed based on USGS Report 2015-5096, which contains data through 2009 only.

Table 3. ND NRCS Hydrologic Method Guidance

Drainage Area (sqmi)	**Hydrologic Zone**	**Slope1085 (%)**	**RUGGED**	**COMPRAT**	**Peak Flow Determination Method (Unrouted / Routed)**
DA <= 3.1	**All**	**All**	**All**	**All**	**EFH2 / TR55[1], HMS**
DA > 4.3	**A**	**1< S <17**	**All**	**All**	**StreamStats / HMS**
DA > 3.1	**B**	**All**	**68 < R < 7820**	**1.4 < C < 3.5**	**StreamStats / HMS**
DA > 3.1	**C**	**All**	**21 < R < 2264**	**All**	**StreamStats / HMS**
3.1 < DA < 25	**All**	**All**	**All**	**All**	**TR55[1], HMS**
All	**All**	**All**	**All**	**All**	**HMS/TR20**

[1]TR55 stream routing reach must be less than 5 miles, and the watershed has insignificant ponding.

[2]Refer to USGS Report 2015-5096 for definition of factors and hydrologic zone map.

The NRCS Arc Toolbox methods for computing topographic (e.g., drainage area and average slope) and runoff curve number inputs should be utilized with LiDAR elevation data in the application of the above methods (excluding StreamStats). Contact ND State Hydrologist for assistance as necessary. StreamStats simply applies the regression equations listed in USGS Report 2015-5096, therefore if LiDAR provides a better estimate of drainage area and other input data, it may be best to run the regression equations outside of StreamStats.

Design the minimum capacity of a natural or constructed auxiliary spillway to pass the peak flow expected from a total design storm of the frequency and duration shown in table 2, less any reduction creditable to the principal spillway discharge and detention storage.

Table 4. Minimum auxiliary spillway capacity

			Minimum Design Storm[2]	
Drainage area *(acre)*	Effective Height of Dam[1] *(feet)*	Detention Storage *(acre-feet)*	Frequency *(years)*	Minimum Duration *(hours)*
20 or less	20 or less	< than 50	10	24
20 or less	> than 20	< than 50	25	24
> than 20	-	< than 50	25	24
All others	-	-	50	24

1. Defined under "Conditions where Practice Applies."

2. Select rain distribution based on climatological region.

Design the auxiliary spillway to safely pass the peak flow through the auxiliary spillway, or route the storm runoff through the reservoir. Start the routing either with the water surface at the elevation of the crest of the principal spillway or at the water surface after a 10-day drawdown, whichever is higher.

Compute the 10-day drawdown from the crest of the auxiliary spillway or from the elevation attained from impounding the entire design storm, whichever is lower. Design the auxiliary spillway to pass the design flow at a safe velocity to a point downstream where the flow will not endanger the dam.

A constructed auxiliary spillway consists of an inlet channel, a control section, and an exit channel. Design the auxiliary spillway with a trapezoidal cross-section. Locate the auxiliary spillway in undisturbed earth or in-situ rock. Design stable side slopes for the material in which the spillway is to be constructed. Design a minimum bottom width of 10 feet for dams having an effective height of 20 feet or more.

Design a level inlet channel upstream from the control section for the distance needed to protect and maintain the crest elevation of the spillway. **The level inlet section shall have a minimum length of 30 feet.** If necessary, curve the inlet channel upstream of the level section to fit existing topography. Design the exit channel grade**, layout, and protections (i.e. dike**) according to 210-NEH-628, Chapter 50, “Earth Spillway Design,” or with equivalent procedures. **Auxiliary spillway exit channel applied shear stress or velocity shall not exceed allowable shear stress or velocity. Applied shear stress can be calculated using eq. 8-1 from NEH Part 654, Chapter 8, Threshold Channel Design, or hydraulic modeling software. Allowable vegetal stress can be calculated using eq. 7-4 from NEH Part 650, Chapter 7, Grassed Waterways, for vegetated exit channels. Reinforcement products such as articulated concrete block and turf reinforcement mats, can be used in exit channels- see CPS 468 (Lined Waterway Outlet) for design guidance. Spillway performance may also be evaluated with computer programs SITES, HEC-RAS, and/or WinDAM C.**

Structural auxiliary spillways
Design chute spillways or drop spillways according to the principles set forth in 210-NEH, Part 650, “Engineering Field Handbook”; and 210-NEH, Section 5, “Hydraulics”; Section 11, “Drop Spillways”; and Section 14, “Chute Spillways.” Design a structural spillway with the minimum capacity required to pass the peak flow expected from a total design storm of the frequency and duration shown in table **3**, less any reduction creditable to the pipe discharge and detention storage .**Design concrete hydraulic structures per NEM Part 536 – Structural Engineering criteria, which states designs shall be in accordance with current ACI 350**

Additional Criteria for Excavated Ponds

Planning

Excavated ponds shall not be installed in wetland until alternative sources of water (wells, springs, dams, pipeline, etc) and/or sites have been considered and it has been determined that there are no practical alternatives.

Runoff
Design a minimum of 1 foot of freeboard above the peak elevation of the design hydrograph. Design a pipe and auxiliary spillway that meets the capacity requirements of table 2. Consider runoff flow patterns when locating the excavated pond and placing the spoil.

Side Slopes
In the excavated area, design side slopes that are no steeper than one horizontal to one vertical.

Watering ramp
When wildlife or livestock need access to stored water, use the criteria in NRCS CPS 575 Animal Trails and Walkways and Watering Facility (Code 614) to design a watering ramp. Ramp shall be constructed with a slope of 4:1 to 5:1, shallower slopes should be

considered for sandy soils.

Inlet Protection
Protect the side slopes from erosion where surface water enters the pond in a natural or constructed channel. **Livestock shall be excluded from the pond, , except along the watering ramp, in easily eroded soils to keep livestock activities out of direct contact with the pond slopes. Easily eroded soils have Plasticity Index (PI) < 15.**

Excavated material
Place the material excavated from the pond so that its weight does not endanger the stability of the pond side slopes and so that the soil will not wash back into the pond by rainfall. Dispose of excavated material in one of the following ways:

- Uniformly spread to a height that does not exceed 3 feet, with the top graded to a continuous slope away from the pond.
- Uniformly place and with side slopes assuming a natural angle of repose. Place excavated material at a distance equal to the depth of the pond, but not less than 12 feet from the edge of the pond.
- Shape to a designed form that blends visually with the landscape.
- Provide for low embankment construction and leveling of surrounding landscape. **When excavated material is used for an embankment, when water depth at the upstream toe of the embankment is 3 feet or more, the structures shall be designed under criteria for Embankment Ponds.**
- Haul material offsite.

The design shall specify designated spoil locations. All spoil shall be removed from wetlands of area 1 acre or smaller. Excavated ponds within wetlands of area greater than 1 acre shall be designed to have spoil placed outside the boundary of the shallow marsh (Type 3) or fresh marsh (Type 2). When abrupt or a rising topography (2 percent or greater) is encountered at a perimeter of the wetland, the spoil may be placed in the wetland. Figure 1 identifies wetland vegetation zones and allowable spoil locations. The North Dakota – Minimal Effect Evaluation Procedure Worksheet (Revised 6/11/02) shall be completed for wetlands affecting USDA participants.

Figure 1. Spoil Placement for pond development, by wetland vegetation zones

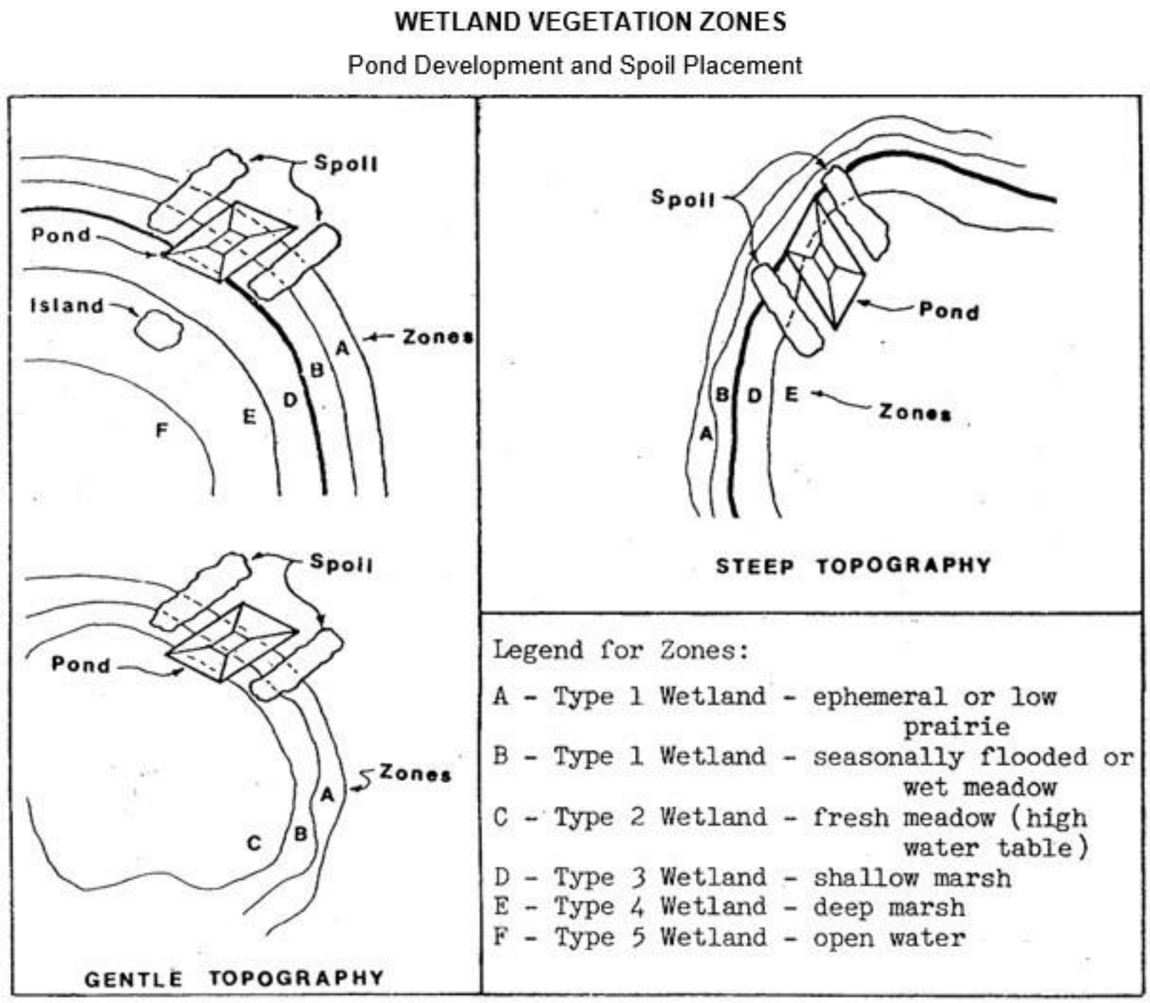

Figure 1: Spoil placement for pond development, by wetland vegetation zones

CONSIDERATIONS

Visual Resource Design

Carefully consider the visual design of ponds in areas of high public visibility and those associated with recreation. The shape and form of ponds, excavated material, and plantings are to relate visually to their surroundings and function.

Shape the embankment to blend with the natural topography. Shape the edge of the pond so it is generally curvilinear rather than rectangular. Shape excavated material so the final form is smooth, flowing, and fitted to the adjacent landscape rather than angular geometric mounds. If feasible, add islands to provide visual interest and attract wildlife.

Fish and Wildlife

Locate and construct ponds to minimize the impacts to existing fish and wildlife habitat.

When feasible, retain trees in the upper reaches of the pond and stumps in the pool area. Shape upper reaches of the pond to provide shallow areas and wetland habitat.

If operations includes stocking fish, use NRCS CPS Fishpond Management (Code 399).

Vegetation

Stockpile topsoil for placement on disturbed areas to facilitate revegetation.

Consider selecting and placing vegetation to improve fish habitat, wildlife habitat, and species diversity.

Water Quantity

Consider effects on components of the water budget, especially—

- Effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
- Variability of effects caused by seasonal or climatic changes.
- Effects on downstream flows and impacts to the environment such as wetlands, aquifers, and social and economic impacts to downstream uses or users.

Water Quality

Consider the effects of—

- Erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances that runoff carries.
- Short-term and construction-related effects of this practice on the quality of downstream watercourses.
- Water level control on the temperature of downstream water to prevent undesired effects on aquatic and wildlife communities.
- Wetlands and water-related wildlife habitats.
- Water levels on soil nutrient processes such as plant nitrogen use or denitrification.
- Soil water level control on the salinity of soils, soil water, or downstream water.
- Earth moving potentially uncovering or redistributing toxic materials.
- Livestock grazing adjacent to the pond. Consider fencing to prevent livestock activities having direct contact with the pond and dam.

PLANS AND SPECIFICATIONS

Prepare plans and specifications that describe the requirements for applying the practice according to this standard. As a minimum, include—

- A plan view of the layout of the pond and appurtenant features.
- Typical profiles and cross sections of the principal spillway, auxiliary spillway, dam, and appurtenant features, as needed.
- Structural drawings adequate to describe the construction requirements.
- Requirements for establishing vegetation or other ground surface protection, as needed.
- Safety features.
- Site-specific construction and material specifications.
- Utility location and notification requirements.

OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for the

operator. As a minimum, include—

- Periodically inspect all structures, earthen embankments, spillways, and other significant appurtenances.
- Promptly repair or replace damaged components.
- Promptly remove trash from pipe inlet and trash rack.
- Promptly remove sediment when it reaches predetermined storage elevations.
- Periodically remove trees, brush, and undesirable species.
- Periodically inspect safety components and immediately repair if necessary.
- Maintain vegetative protection and immediately seeding bare areas, as needed.
- Prevent the establishment of woody vegetation on constructed embankment fill and around spillway appurtenances.

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