Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

POND

Code 378

(No.)

DEFINITION

A pond is a water impoundment made by constructing an embankment, by excavating a dugout, or by 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 by both the excavation and the 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

A pond stores water for livestock, fish and wildlife, recreation, fire control, erosion control, flow detention, and other uses such as improving water quality.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all excavated ponds. It also applies to embankment ponds that meet all of the criteria for low-hazard dams as listed below:

- 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.
- 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 Purposes

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 in accordance with requirements of NRCS National Engineering Manual (NEM), 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) Code 342, Critical Area Planting. When necessary to provide surface protection where climatic conditions preclude the use of seed or sod, use the criteria in CPS Code 484, Mulching, to install inorganic cover material such as gravel.

The downstream area below the dam must be evaluated carefully to determine what impact a sudden breach of the proposed dam would have. This evaluation must consider all existing improvements and those improvements that may reasonably be expected to be made during the useful life of the structure. The results of this examination provide for the proper hazard class of the dam. Use NC-ENG-34, Hazard Classification Data Sheet, for documentation of hazard class determination.

Any dam that is 25 feet or over in height and has an impoundment capacity of 50 acre-feet or more (as defined by the NC Dam Safety Law) or is considered high hazard, will require a permit under the North Carolina Dam Safety Law. NRCS hazard classification may differ from that of the NC Department of Environmental Quality (DEQ). Pipe materials and spillways for dams constructed under a dam safety permit will meet the requirements of DEQ when they are more stringent than NRCS requirements.

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 (1) a natural or constructed auxiliary spillway, (2) a combination of a principal spillway and an auxiliary spillway, or (3) a principal spillway.

Select a site that has an adequate supply of water for the intended purpose via surface runoff, groundwater, or a supplemental water source. Water quality must be suitable for its intended use.

Drainage area. The drainage area above the pond must be 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 so that surface runoff and groundwater will provide an adequate supply of water for the intended purpose unless an alternate water source exists to serve this purpose.

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. Areas at design normal pool and top of dam shall be measured for determining storage volumes for flood routing and for determining Dam Safety Law requirements.

Soils in the pool area shall have appropriate seepage rates to obtain and maintain adequate water levels. Appropriate seepage rates will be obtained utilizing the natural environment, by manipulation of the soils, or by lining the pool area, using the criteria in CPS Code 520 Pond Sealing or Lining, Compacted Soil Treatment or CPS Code 521 Pond Sealing or Lining, Flexible Membrane.

Criteria Applicable to Embankment Ponds.

Geological investigations. Use pits, trenches, borings, and reviews of existing data or other suitable means of investigation to characterize materials within the embankment foundation, principal and auxiliary spillway, and borrow areas. Classify soil materials using the Unified Soil Classification System (ASTM D2487), and to support the design of the pond.

Foundation and Embankment. The foundation shall provide stable support for the embankment under all saturation and loading conditions and provide sufficient resistance to seepage. The embankment shall have sufficient strength to remain stable under all saturation and loading conditions by selecting, obtaining, and compacting mineral earth fill materials. The compacted embankment shall have sufficiently low permeability to prevent harmful seepage. A sheepsfoot roller shall be used when the earth fill has a moderate to high clay content.

Foundation cutoff. Design a cutoff of relatively impervious material under the dam and up the abutments to prevent 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, not less than 2 feet in depth. 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. Design cutoff side slopes no steeper than one horizontal to one vertical.

Seepage control. Include seepage control if (1) foundation cutoff does not intercept pervious layers, (2) seepage could create undesired wet areas, (3) embankment stability requires seepage control, or (4) special problems require drainage for a stable dam. Control seepage by (1) foundation, abutment, or embankment filters and drains; (2) reservoir blanketing; or (3) a combination of these measures.

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 dams used as public roads. 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 dams.

Total height of dam *(feet)*	Top width *(feet)*
Less than 10	8
10–19.9	10
20–24.9	12
25–34.9	14
35	15

Side slopes. Design each side slope with a ratio of two horizontal to one vertical (2:1) or flatter. Design the sum of the upstream- and downstream-side slopes with a ratio of five horizontal to one vertical (5:1) or flatter. As required, design benches or flatten side slopes to assure stability of all slopes for all loading conditions. Dams to be mowed shall have side slopes of three horizontal to one vertical (3:1) or flatter.

Slope protection. Design special measures such as berms, rock riprap, sand-gravel, soil cement, or 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.

Freeboard. Design a minimum of 1.0 feet of freeboard between design high-water-flow elevation in the auxiliary spillway and the top of the settled embankment. Design a minimum 2.0 feet of elevation difference between the crest of the auxiliary spillway and the top of the settled embankment when the dam has more than a 20-acre drainage area or more than 20 feet in effective height. Design a minimum of 1.0 feet of freeboard above the peak elevation of the routed 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. This increase shall not be less than 10 percent **unless** the maximum thickness of layer before compaction is 9 inches or less **and** compaction is equivalent to or better than the following: The routing of the loaded hauling and spreading equipment over the fill in such a manner that every point on the surface of each layer of fill will be traversed by not less than one tread track of the loaded equipment traveling in a direction parallel to the main axis of the fill. Under these conditions, the allowance for settlement may be reduced to 5 percent.

Principal spillway and pipe conduit through the embankment. Design a pipe conduit with needed appurtenances through the dam, except where rock, concrete, or other types of lined principal spillways are used.

Design adequate pipe conduit capacity to discharge long-duration, continuous, or frequent flows without causing flow through the auxiliary spillway, using minimum criteria in Table 2. Design a principal spillway pipe with a minimum inside diameter of 4 inches. Design pipe with a minimum inside diameter of 1-1/4 inches for water supply pipes or for pipes used for any other purpose. Supply pipes shall be equipped with valves and seepage control.

Table 2. Minimum Principal Spillway Capacity

Effective Height *(ft)*[1]	Principal Spillway Design Storm Frequency (yr)[2,3]
< 20	1
20 – 24.9	2
25 – 29.5	5
30 - 35	10

[1]. As defined under “Conditions where Practice Applies”.
[2]. Select rain distribution based on climatological region.
[3]. 24 hour duration

Design a minimum of 0.5-feet 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 1.0-foot difference when the dam has a drainage area of over 20 acres.

Provide an antivortex device for a pipe conduit designed for pressure flow. Design the inlet and outlet to function for the full range of flow and hydraulic head anticipated.

Design pipe conduits using ductile iron, welded steel, corrugated steel, corrugated aluminum, reinforced concrete (pre-cast 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. Dissimilar metals, such as aluminum and steel, must not be installed in direct contact with each other.

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

The minimum thickness of flexible pipe shall be SDR 26, Schedule 40, Class 100, or 16 gage as appropriate for the particular pipe material. Pipe strengths shall not be less than the values shown in Tables 3 and 4 for polyvinyl chloride (PVC), steel, and aluminum pipe.

Table 3. Acceptable PVC pipe [1]

Nominal Pipe size (in)	Schedule or Standard Dimension Ratio	Maximum depth of fill (ft)
4 or less	Schedule 40	15
	Schedule 80	20
	SDR 26	10
6,8,10,12	Schedule 40	10
	Schedule 80	15
	SDR 26	10

[1] Polyvinyl chloride pipe, PVC 1120 or PVC 1220, conforming to ASTM D-1785 or ASTM D-2241.

Table 4. Minimum gage for corrugated metal pipe (2-2/3 in X 1/2 in and 3 in X 1 in) [1]

Fill height (ft)	Minimum gage for steel pipe with diameter (in) of					
	≤21	24	30	36	42	48
1-15	16	16	16	14	12	10
15-20	16	16	16	14	12	10
20-25	16	16	14	12	10	10

Fill height (ft)	Minimum thickness (in) of aluminum pipe[2] with dia. (in) of			
	≤21	24	30	36
1-15	0.06	0.06	0.075	0.075
15-20	0.06	0.075	0.105	0.105
20-25	0.06	0.105	0.135	----[3]

[1] Pipe with 6, 8, and 10-in. diameters has 1-1/2 in X 1/4 in corrugations.
[2] Riveted or helical fabrication.
[3] Not permitted.

Design connections of flexible pipe to rigid pipe or other structures to accommodate differential movements and stress concentrations. Design and install all pipe conduits 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. “Dimple” connecting bands shall not be used.

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

Design outlet structures, such as cantilever pipe outlet sections and impact basins, to dissipate energy as needed.

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. Aluminum surfaces to be covered with concrete shall be coated with an appropriate material such as bituminous coating.

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. 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.

Outlet Works. The principal spillway shall outlet into a plunge basin or other energy dissipating device. The outlet channel shall be of adequate size and capacity to convey the pipe discharge without submerging the pipe outlet and shall be aligned with the barrel.

Filter diaphragms. When the effective height of the dam is 15 feet or greater and the effective storage of the dam is 50 acre-ft. or more, provide filter diaphragms to control seepage on all pipes extending through the embankment with inverts below the peak elevation of the routed design hydrograph.

Design filter diaphragms or alternative measures, such as anti-seep collars, to control seepage on pipes extending through all other embankments or for pipes with inverts above the peak elevation of the routed design hydrograph.

Design the filter diaphragm in accordance with the requirements of 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. The minimum cover on the diaphragm shall be at least 2 feet as measured to the nearest surface of the embankment.

The diaphragm shall be located downstream of the core zone and/or cutoff trench, maintaining the minimum cover as indicated above. For zoned embankments, if the downstream shell is more pervious than the diaphragm material, the diaphragm shall be located at the downstream face of the core zone.

The drainage diaphragm will outlet at the embankment downstream toe using a drain backfill envelope continuously along the pipe to where it exits the embankment or by use of an adequate pipe drain. Drain fill shall be protected from surface erosion by using filter fabric covered by small riprap. Adequate protection of the outlet, including adequate animal guards, shall be provided.

Ensure filter diaphragm functions both as a filter for adjacent base soils and as a drain for seepage that it intercepts. Materials for the filter diaphragm shall meet the requirements of NEH Part 628, Chapter 45, Filter Diaphragms, Section 628.4503(d), Filter and Drain Gradation.

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. The anti-seep collars shall be located in the normal saturation zone. Use a collar material that is compatible with the pipe material.

When using anti-seep collars, 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 conduit, unless the watershed does not contain trash or debris that could clog the conduit.

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 conduit 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 routed design hydrograph and the trash that comes to it without overtopping the dam. The minimum criteria for acceptable use of a closed conduit principal spillway without an auxiliary spillway consist of a conduit 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.

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 5, less any reduction creditable to the conduit discharge and detention storage.

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 10 days' 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 or compacted earth or in-situ rock. The freeboard portion of the spillway depth may be against compacted fill for ponds designed with a pipe conduit minimum capacity of the 2-year, 24 hour storm. A portion of the design flow may be located in compacted earth, if approved by the engineer. Design for 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. If necessary, curve the inlet channel upstream of the level section to fit existing topography. Design the exit channel grade in accordance with NEH Part 628, Chapter 50, Earth Spillway Design, or with equivalent procedures.

Table 5. Minimum auxiliary spillway capacity

Drainage area *(acre)*	Effective height of dam[1] *(feet)*	Detention storage *(acre-feet)*	Minimum design storm[2]	
			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.

Structural auxiliary spillways. When used for principal spillways or auxiliary spillways, design chute spillways or drop spillways according to the principles set forth in NEH, Part 650, Engineering Field Handbook; and 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 5, less any reduction creditable to the conduit discharge and detention storage.

Ponds in Series. Hydrology for all ponds in series will be evaluated by an engineer with adequate expertise in this field. The hydrologic criteria and procedures for the design of an upper dam shall not be less than that used for dams downstream if failure of the upper dam would contribute to failure of the lower dam. For dams not flood routed, the volume of detention storage in the lower dam shall be based on runoff from the entire drainage area with appropriate reduction due to detention storage in the upper pond. The release rate of the pipe spillway in the downstream pond shall be greater than the pipe spillway of the upstream pond. The auxiliary spillway of the lower site shall be designed to safely pass the peak flow from the entire drainage area as if the upper pond was not in place. For ponds which are flood routed, procedures as outlined in TR-210-60, "Earth Dams and Reservoirs" shall be followed.

Reservoir Clearing. Reservoir areas shall be cleared at least to the elevation of the crest of the principal spillway however, clearing may not be required for shallow water impoundments or other ponds constructed for the purpose of wildlife habitat. Stumps cut off at least 24" below the normal water line may remain for fish habitat. The minimum area cleared must extend the full length of the dam for a distance of at least 400 feet upstream from the principal spillway and of the auxiliary spillway. When the reservoir area exceeds 100 acres, North Carolina law requires complete clearing of the reservoir area.

Criteria for Excavated Ponds

Runoff. Design a minimum of 1.0 feet of freeboard above the peak elevation of the routed design hydrograph. Design a pipe and auxiliary spillway that will meet the capacity requirements of Tables 2 and 5. A pipe spillway is not required if surface runoff is diverted away from the pond. Consider runoff flow patterns when locating the excavated pond and placing the spoil.

Side slopes. Design stable side slopes in the excavated area 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 Code 614, Watering Facility, to design a watering ramp.

Inlet protection. Protect the side slopes from erosion where surface water enters the pond in a natural or excavated channel.

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. Side slopes of spread material shall be no steeper than 4:1. 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 or shape reasonably well, 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.
- Haul material offsite.

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 to their function.

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

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

When feasible, retain structures such as 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 include stocking fish, use CPS Code 399, Fishpond Management.

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 upon components of the water budget, especially—

- Effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.
- Variability of effects caused by seasonal or climatic changes.
- Effects on downstream flows and impacts to 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 temperatures 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.
- Potential for earth moving to uncover or redistribute toxic materials.
- Livestock grazing adjacent to the pond. Consider fencing to keep livestock activities out of 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 the following items:

- 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
- Soil Boring Log (NC ENG-538 or equivalent)
- Structural drawings adequate to describe the construction requirements
- Requirements for vegetative establishment and/or mulching, as needed
- Safety features
- Site-specific construction and material requirements

OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for the operator.

As a minimum, include the following items in the operation and maintenance plan:

- Periodic inspections of all structures, earthen embankments, spillways, and other significant appurtenances
- Prompt repair or replacement of damaged components
- Prompt removal of sediment when it reaches predetermined storage elevations
- Periodic removal of trees, brush, and undesirable species

- Periodic inspection of safety components and immediate repair if necessary
- Maintenance of vegetative protection and immediate seeding of bare areas as needed

REFERENCES

American Society for Testing and Materials. Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System), ASTM D2487. West Conshohocken, PA.

USDA NRCS. Engineering Technical Releases, TR-210-60, Earth Dams and Reservoirs. Washington, DC.

USDA NRCS. National Engineering Handbook (NEH), Part 628, Dams. Washington, DC.

USDA NRCS. NEH, Part 633, Soil Engineering. Washington, DC.

USDA NRCS. NEH, Part 636, Structural Engineering. Washington, DC.

USDA NRCS. NEH, Part 650, Engineering Field Handbook. Washington, DC.

USDA NRCS. National Engineering Manual. Washington, DC.

NC Dam Safety Law - G.S. 143-215.24

NC Administrative Code - 15A NCAC 02K.0100

NC Administrative Code - 15A NCAC 18B.0100