Citation


History

North Carolina’s Dam Safety Law was passed in 1967. It was not funded at a significant level until the mid 1970’s. Incidences such as the failure of Bear Wallow dam in 1976 that took the lives of four family members raised awareness and resulted in increased funding. In 1989, the failure of a dam that did not meet the height and impoundment capacity for jurisdiction resulted in loss of life and significant property damage. At this time the dam safety program was charged with regulating all high hazard potential dams. There has been a gradual but steady increase in the size and effectiveness of the program until 2001 when state budget shortfalls have prevented further expansion.

Definitions/Dam Classification

*Dam* means any structure which is 15 feet or higher and capable of impounding 10 acre-feet or more of water, and appurtenant works for the impoundment or diversion of water. *Dam height* is measured from the lowest existing elevation of the crest to the lowest point of natural ground, including any stream channel along the downstream toe of the dam. (Rule .0104) Dam height is measured from the highest point on the crest of the dam to the lowest point on the downstream toe. (Rule .0223). High hazard dams smaller than this are subject to state jurisdiction.

**Hazard Classification** (Rule .0105)

<table>
<thead>
<tr>
<th>Class</th>
<th>Failure results in</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - Low</td>
<td>Dams located where failure may damage uninhabited low value non-residential buildings, agricultural land, or low volume roads.</td>
</tr>
<tr>
<td>B - Intermediate</td>
<td>Dams located where failure may damage highways or secondary railroads, cause interruption of use or service of public utilities, cause minor damage to isolated homes, or cause minor damage to commercial and industrial buildings. Damage to these structures will be considered minor only when they are located in back water areas not subjected to the direct path of the breach flood wave; and they will experience no more than 1.5 feet of flood rise due to breaching above the lowest ground elevation adjacent to the outside foundation walls or no more than 1.5 feet of flood rise due to breaching above the lowest floor elevation of the structure, the lower of the two elevations governing. All other damage potential will be considered serious.</td>
</tr>
<tr>
<td>C - High</td>
<td>Dams located where failure will likely cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, primary highways, or major railroads.</td>
</tr>
</tbody>
</table>
Design Criteria

Hydrologic (Rule .0205)

(a) All dams shall have a spillway system with capacity to pass a flow resulting from a design storm indicated in (e) of this Rule for a hazard classification appropriate for the dam, unless the applicant provides calculations, designs, and plans to show that the design flow can be stored, passed through, or passed over the dam without failure occurring.

(b) A vegetated earth or unlined emergency spillway will be approved when computations indicate that it will pass the design storm without jeopardizing the safety of the structure. The risk of recurring storms, excessive erosion, and inadequate vegetative cover will be considered acceptable in such a spillway when its average frequency of use is predicted to be no more frequent than once in 25 years for existing class B and for class A dams except for small class A dams designed in accordance with all design criteria established by the U.S.D.A, Soil Conservation Service, and as contained in Engineering Standard 378 of the U.S.D.A., Soil Conservation Service; once in 50 years for new class B, small and medium new class C, and existing class C dams; and once in 100 years for large and very large new class C dams. The dam sizes referred to in this Subsection are defined in (e) of this Rule.

(c) Lined Spillways and Channels. The design report shall include design data criteria for open channel, drop, ogee, and chute spillways and other spillway types that include crest structures, walls, channel lining, and miscellaneous details. All masonry or concrete structures shall have joints that are relatively water-tight and shall be placed on foundations capable of sustaining applied loads without undue deformation. Provisions must be made for handling leakage from the channel or underseepage from the foundation that might cause saturation of underlying materials or uplift against the undersurfaces.

(d) Within 15 days following passage of the design storm peak, the spillway system shall be capable of removing from the reservoir at least 80 percent of the water temporarily detained in the reservoir above the elevation of the primary spillway.

(e) It is recognized that the relationships between valley slope and width, total reservoir storage, drainage area, other hydrologic factors, and specific cultural features have a critical bearing on determining the safe spillway design flood. Rational selection of a safe spillway design flood for specific site conditions based on quantitative analysis is acceptable. The spillway should be sized so that the increased downstream damage resulting from overtopping failure of the dam would not be significant as compared with the damage caused by the flood in the absence of dam overtopping failure. A design storm more frequent than once in 100 years will not be acceptable for any class C dam. In lieu of quantitative analysis, the following tables shall be used as criteria for spillway design storms and permissible velocities for vegetated earth spillways.
CRITERIA FOR SPILLWAY DESIGN STORMS
SIZE CLASSIFICATION

<table>
<thead>
<tr>
<th>Size</th>
<th>Total Storage (Ac-Ft)¹</th>
<th>Height(ft)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>less than 750</td>
<td>less than 35</td>
</tr>
<tr>
<td>Medium</td>
<td>equal to or greater than 750 and less than 7,500</td>
<td>equal to or greater than 35 and less than 50</td>
</tr>
<tr>
<td>Large</td>
<td>equal to or greater than 7,500 and less than 50,000</td>
<td>equal to or greater than 50 and less than 100</td>
</tr>
<tr>
<td>Very Large</td>
<td>equal to or greater than 50,000</td>
<td>equal to or greater than 100</td>
</tr>
</tbody>
</table>

The factor determining the largest size shall govern.

MINIMUM SPILLWAY DESIGN STORMS

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Size</th>
<th>Spillway Design Flood (SDF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (Class A)</td>
<td>Small</td>
<td>50 year</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>100 year</td>
</tr>
<tr>
<td></td>
<td>Large</td>
<td>1/3 PMP</td>
</tr>
<tr>
<td></td>
<td>Very Large</td>
<td>1/2 PMP</td>
</tr>
<tr>
<td>Intermediate (Class B)</td>
<td>Small</td>
<td>100 Year</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>1/3 PMP</td>
</tr>
<tr>
<td></td>
<td>Large</td>
<td>1/2 PMP</td>
</tr>
<tr>
<td></td>
<td>Very Large</td>
<td>3/4 PMP</td>
</tr>
<tr>
<td>High (Class C)</td>
<td>Small</td>
<td>1/3 PMP</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>1/2 PMP</td>
</tr>
<tr>
<td></td>
<td>Large</td>
<td>3/4 PMP</td>
</tr>
<tr>
<td></td>
<td>Very Large</td>
<td>PMP</td>
</tr>
</tbody>
</table>

Seismic North Carolina currently has no seismic criteria.

Structural Stability and Slope Protection (Rule .0208)

(a) Design and construction of dams to assure structural stability shall be consistent with modern engineering practice. The scope and degree of precision that will be required for a specific project will depend on the conditions of the site and the damage...
potential of the proposed structure. Consideration in design for structural stability shall include, but are not necessarily limited to, the following:

1) the hazard potential of the dam under present downstream conditions and under conditions which would likely develop during the life of the reservoir;
2) foundation bearing capacity, compressibility, and permeability; the extent and reliability of the site investigation; and the predictability of the site and foundation conditions;
3) the reliability of construction materials, such as borrow soils, in terms of sufficient volume to complete construction without unanticipated interruption and in terms of predictability of physical properties such as strength, permeability, and compressibility;
4) durability of construction materials;
5) construction conditions at the site;
6) the degree of quality control to be exercised during construction;
7) pore pressure build-up during construction;
8) the rate of filling the reservoir and the rate of possible reservoir drawdown;
9) tail water conditions and the impact of tail water drawdown;
10) possible effects of landslides and subsurface solution activity on the structural stability of the dam and spillway structures;
11) the extent of piezometers and other devices which will be used to monitor the completed dam and the degree of access for inspections.

(b) Slope stability analyses should be considered by the design engineer for all embankment dams and may be required for class B and class C dams. Where slope stability analyses are required, documentation in the final design report shall include the design cross section(s) showing the soil parameters assumed for analysis, the location of the phreatic surface assumed for analysis, stability computations, and the location and computed safety factor(s) for the most critical circle(s) or failure wedge(s). A minimum factor of safety of 1.5 for slope stability for normal loading conditions, and 1.25 for quick drawdown conditions and for construction conditions, shall be required unless the design engineer provides a thoroughly documented basis for using other safety factors.

(c) Foundation bearing capacity and sliding base analyses should be considered for all dams and may be required for class B and C dams. Where bearing capacity or sliding base analyses are required, documentation of assumptions, computations, and safety factors shall be included in the final design report. A minimum factor of safety against bearing capacity and sliding wedge failure of 2.0 shall be required unless the design engineer provides a thoroughly documented basis for using other safety factors.

(d) Resistance of appurtenant structures against flotation uplift shall be provided for all dams. If the structures are anchored by dead weight alone, the buoyant weight shall be used for analysis and the minimum factor of safety shall be 1.15. If the structures are anchored to soil or rock, the minimum factor of safety for that portion of the resistance provided by soil or rock anchorage shall be 2.0 unless the design engineer provides a thoroughly documented basis for using a lower safety factor.
(e) For concrete, masonry, or other similar dams of relatively narrow cross section, resistance against overturning under maximum design loading conditions shall be considered; overturning stability computations shall be required for class B and class C dams. Where overturning analyses are required, the computations shall be included in the final design report. The minimum safety factor against overturning under maximum design loading conditions shall be 1.5 unless the design engineer provides a thoroughly documented basis for using a lower safety factor.

(f) The anticipated reservoir and tailwater drawdown conditions shall be considered in all stability computations and shall be included in the design documents provided in the final design report.

(g) The slopes must be protected against erosion by wave action, and the crest and downstream slope must be protected against erosion due to wind and rain. Riprap and other erosion protection shall be provided over the full range in stage between the lowest drawdown elevation and at least two feet above full normal pool. Exceptions for slowly rising reservoirs, such as waste storage facilities, may be approved in writing by the Director.

Seepage Control (Rule .0208)

(a) All dams shall be designed and constructed to prevent the development of instability due to excessive seepage forces, uplift forces, or loss of materials in the embankment, abutments, spillway areas, or foundation. Seepage analysis for design shall identify areas having high internal uplift or exit gradients.

(b) The design may include an embankment internal drainage system, a zoned embankment, a foundation cut-off, an upstream blanket, a sufficiently wide homogeneous section, or other methods to protect against instability from excessive seepage forces or high hydraulic gradients.

(c) For class C dams, a flow net analysis shall be made to determine the location of the phreatic surface, flow lines, and equipotential lines within the embankment and its foundation. This analysis may be based on graphical construction, electrical or liquid analogs, soil prototype methods, or other accepted methods. The flow net and stability analysis shall use the maximum operating pool level with not less than five feet of clear water at the surface. Possible fluctuations in tail water elevation shall be included in the analysis. The flow net and seepage analysis shall be documented in the final design report, as required by .0201(d)(4) of this Section.

(d) Piezometers for confirming the location of the phreatic surface assumed for seepage and slope stability analyses should be considered by the design engineer for class A and class B dams and shall be required for class C dams. Where piezometers are required, their design, depths, and locations shall be provided as required in .0201(d) and .0212(b) of this Section.

Conduits (Rule .0206)

(a) A conduit shall be provided to drain each reservoir. The conduit design shall include the computation of the minimum time required to drain the reservoir.
(b) All pipe conduits shall convey water at the design velocity without damage to the interior surface.

(c) Protection shall be provided to prohibit unsafe seepage along conduits through the dam, abutments, and foundation. The specific design for seepage protection along conduits shall be shown in the drawings and specifications.

(d) Adequate allowances shall be incorporated in the design to compensate for differential settlement and possible elongation of the pipe conduit.

(e) Trash racks shall be installed at the intake of conduits to prevent clogging the conduit.

(f) Pipe Conduit Spillway Materials
   
   (1) Pipe conduits shall be designed to support the total external loads in addition to the total internal hydraulic pressure without leakage.

   (2) Reinforced or Prestressed Concrete Pipe Conduits
      
      (A) All conduits are to be designed and constructed to remain watertight under maximum anticipated hydraulic pressure and maximum probable joint opening, including the effects of joint rotation and extensibility.

      (B) Provisions for safe movement of the barrel are to be provided at each joint in the barrel and at the junction of the barrel and riser or inlet. Cradles are to be articulated if constructed on a yielding foundation.

      (C) The engineer shall submit the final design details of the proposed pipe to be used for all class A dams where the height of the dam exceeds 35 feet and all class B and C dams.

   (3) Corrugated Metal Pipe Conduits
      
      (A) Corrugated metal pipe shall not be used in class A dams over 35 feet high or in class B and C dams, except for special cases when the design engineer can adequately demonstrate satisfactory performance.

      (B) Corrugated metal pipe may be used in class A dams which are less than 35 feet high.

      (C) Corrugated metal conduits shall have watertight connecting bands designed and installed to remain watertight under maximum anticipated hydrostatic head and joint rotation.

      (D) Flange type couplings shall not be used for corrugated metal pipe or corrugated steel pipe where the diameter exceeds 12 inches unless the applicant produces computations to verify that the flanges and the pipe conduit are of such design to safely support the total external loads in addition to the total internal hydraulic pressure without leakage.

(g) Dissipating Devices: All gates, valves, conduits and concrete channel outlets shall be provided with a dissipator designed and constructed to control erosion and prevent damage to the embankment or the downstream outlet or channel.

(h) In the case of repair to an existing dam, the engineer may determine that the conduit should not be repaired or replaced and shall submit reasoning to support this
determination in the application for the Certificate of Approval to repair. The Director shall approve, disapprove, or approve in part this determination.

**Design Life of the Dam and Reservoir (Rule .0209)**

(a) The selection of materials and equipment to be used in a dam and all of its appurtenant features shall either be based on sufficient quality and durability to satisfactorily function throughout the design life or shall provide for safe and economical replacement within the design life span.

(b) The design life of a dam and reservoir is the period of time the dam and reservoir can be expected to perform effectively as planned. The design life of a dam shall be determined by the following:

1. the time required to fill the reservoir with sediment from the contributing watershed,
2. the durability of appurtenances and materials used to construct the dam,
3. the time required to permanently fill a waste treatment or storage facility with waste,
4. the time required to perform the specific function for which the dam was designed.

**Sediment Control (Rule .0210)**

Sediment control related to earth moving activities involved in construction or repair of dams shall be provided in accordance with the North Carolina Sediment Pollution Control Act of 1973 (G.S. 113A-50 through 113A-66). Devices for sediment control during drainage of a reservoir shall be provided; exceptions for emergency drainage of a reservoir may be approved by the Director.

**Investigations (Rule .0204)**

(a) General. The applicant shall be required to complete all investigations prior to submission of the final plans and application. The scope and the degree of precision that will be required for a specific project will depend on the conditions of the site and the hazard created by the proposed structure.

(b) Foundations and Abutments. The foundation and abutments investigation shall consist of borings, test pits, and other subsurface exploration necessary to assess the soil, rock, and groundwater conditions. Geologic profiles and a geologic report prepared by a qualified geologist may be required for class B dams and shall be required for class C dams.

(c) Construction Materials. Specifications for construction materials shall establish minimum acceptance criteria so that design properties are achieved. If the use of on site borrow materials is specified, exploration, testing, and calculations should be performed to indicate that there are sufficient quantities of material available that meet the design criteria.
(d) Surveys. Surveys shall be made with sufficient accuracy to locate the proposed construction and to define the volume of the storage in the reservoir. The downstream area shall be investigated in order to delineate the area of potential damage in case of failure. Locations of centerlines, and other horizontal and vertical control points, shall be shown on a map of the site.

(e) Hydrologic Investigation. The drainage area shall be determined. Both present and projected future land use shall be considered in determining the runoff characteristics of the drainage area. The most severe of these two conditions shall be used in the design. All hydrologic assumptions and design calculations shall be included in the report.

Jurisdiction/Powers of Department

The North Carolina Department of Environment and Natural Resources is responsible for the safety of dams and for the adoption of all rules and regulations designed to protect life and property. (Rule .0103) The department has the power to inspect, and approve permits for construction, alteration, repair, and removal of dams, and to call for remedial work as necessary (Rule .0200). The department is authorized to collect fees for dam construction or removal plans. Any authorized personnel of the department may make an inspection as deemed necessary to ensure compliance. (Rule .0217) The department has the power to cite non-compliance and assess civil penalties. (Rule .0221) The director may in the event of an emergency take any measures deemed necessary to protect life and property. (Rule .0302). Minimum release requirements from dams may be required under Dam Safety Law.

Permit/Approval Process

No one shall construct, repair, alter, or remove a dam without obtaining a permit from the department 10 days before start of construction. The application must contain location of the dam, purpose, proposed construction, maps, specifications, and descriptions of surrounding properties, geologic investigations and technical provisions. The director shall within 60 days of receipt, notify applicant of approval or denial. No construction shall begin until Certificate of Approval is obtained. (Rule .0202) All plans and specs shall be prepared by a professional engineer. (Rule .0203) Financial liability for remedial work lies with the owner. (Rule .0302) Minimum design spillway criteria are required and are found in Rule .0205. Final approval must be granted by the department before a dam may be impounded. (Rule .0220)

Fees

The 1990 state general assembly authorized the use of fees for permitting of dam construction and removal. There is a $200 non-refundable application processing fee with filing of application for construction or removal of a dam. The following additional processing fees are due when as-built plans are submitted and are based upon a percentage of the cost of construction and removal of the dam.

<table>
<thead>
<tr>
<th>Costs of Construction</th>
<th>Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between $10,001 and $100,000</td>
<td>2%</td>
</tr>
<tr>
<td>Between $100,001 and $500,000</td>
<td>1.5%</td>
</tr>
</tbody>
</table>
Between $500,001 and $1,000,000 1.0%
Over $1,000,000 0.5%

The total fee cannot exceed $50,000.

**Inspection Process**

An effort is made by the department to inspect all Class A and B dams at least once every five years, and Class C dams are inspected once every 2 years. Inspection during construction shall occur as deemed necessary by the department. (Rule .0217) The engineer in charge must provide adequate inspection during construction in accordance with Rules .0216-.0217. No inspection fees are required for inspections made by the department.

**Frequency of Inspections**

<table>
<thead>
<tr>
<th>Hazard Classification</th>
<th>Inspection Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>2 years</td>
</tr>
<tr>
<td>Significant</td>
<td>5 years</td>
</tr>
<tr>
<td>Low</td>
<td>5 years</td>
</tr>
</tbody>
</table>

**Owner Non-Compliance/Violations/Penalties**

The director may issue an order directing the owner of a dam to make, in not less than 90 days from issuance of the order, any maintenance, alteration, or change in construction upon a finding that the dam is not maintained in good repair or operating condition, or if it is determined that the dam is dangerous to life or property. (Rule .0302) Remedial work is to be paid for by the owner. Penalties for violations include criminal penalties of $100 - $1000, civil penalties of up to $500 per day of violation, and injunction relief.

**Emergencies**

The department may issue orders for remedial work, and may take any necessary actions in an emergency to protect life and property (Rule .0302). Emergency Action Plans are required as a condition of impoundment for all new high hazard dams.

**Liability**

Dam owners are in no way relieved of any liabilities or legal obligations. (Rules .0302) G.S. 143-215.35 of the statutes absolves the state from liability from damages caused by a dam failure.

**Oversight**

Any person whose application has been disapproved, been denied final approval or whose dam has been issued an order for remedial work or construction changes is entitled to a hearing before the commission within 10 days of being notified by the department (Rules .0402).
<table>
<thead>
<tr>
<th>State Citations</th>
<th>Statute</th>
<th>Regulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last Amended</td>
<td>1995</td>
<td>April 1995</td>
</tr>
</tbody>
</table>

State Web Site: [http://www.dlr.enr.state.nc.us/pages/damsafetyprogram.html](http://www.dlr.enr.state.nc.us/pages/damsafetyprogram.html)