E.31. New York
Guidelines for Design of Dams

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New York State Department of Environmental Conservation

George E. Pataki, Governor

John P. Cahill, Commissioner
# GUIDELINES FOR DESIGN OF DAMS

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1.0 INTRODUCTION

1.1 General

The Department of Environmental Conservation receives many requests for detailed information about designs for dams requiring a permit under Article 15, Section 0503 of the Environmental Conservation law. This brochure has been developed by the department for the general guidance of design engineers.

These guidelines represent professional judgment of the Dam Safety Section's staff engineers. The guidelines convey sound engineering practices in an average situation. Where unusual conditions exist and the guidelines are not applicable, it is the duty of the design engineer to notify the department which will then consider deviation from the guidelines.

Since these are only general guidelines for small dam construction in an average situation, compliance will not necessarily result in approval of the application. The determination by the department of the acceptability of the design and adequacy of the plans and specifications will be made on a case-by-case basis. The primary responsibility of proper dam design shall continue to be that of the applicant.

In the administration of this law, the department is concerned with the protection of both the health, safety and welfare of the people and the conservation and protection of the natural resources of the State. (See Reference 1 and 2).

Water stored behind a dam represents potential energy which can create a hazard to life and property located downstream of the dam. At all times the risks associated with the storage of water must be minimized. This document deals with the engineering guidelines for the proper design of a dam. In order for a dam to safely fulfill its intended function, the dam must also be constructed, operated and maintained properly.

Supervision of construction or reconstruction of the dam by a licensed professional engineer is required to insure that the dam will be built according to the approved plans. See Article 15-0503, Item 5 of the New York State, Environmental Conservation Law (Reference 1).

For the proper operation and maintenance of a dam, see "An Owners Guidance Manual for the Inspection and Maintenance of Dams in New York State" (Reference 6).

1.2 Application

A permit is required if the dam:

- is at least 10 feet high or
- stores 1 million gallons (3.07 acre feet) or
- has a drainage area of 1 square mile.

Waste surface impoundments which are large enough to meet the above mentioned criteria shall not require an Article 15 dam permit. Hazardous waste surface impoundments will continue to be regulated by the Bureau of Hazardous Waste Technology, Division of Hazardous Substances.
Regulation of the Department of Environmental Conservation, under 6NYCRR-Part 373, Hazardous Waste Management Regulation. Surface impoundments which are part of an approved waste water treatment process will be regulated within a SPDES permit issued by the Division of Water.

1.3 Application Forms

Applications, including the Supplement D-1 (hydrological, hydraulic and soils information), can be obtained from and should be submitted to the Regional Permit Administrator. The addresses of the Regional Permit Administrators are shown on page 31. Detailed information on application procedures is contained in the Uniform Procedures Regulations, Part 621.

Information on all pertinent items should be given. Construction plans and specifications should be prepared in sufficient detail to enable review engineers to determine if the proposed design and construction is in compliance with department guidelines. Thorough engineering review will be given each application. The time for this review and any additional time if revisions are necessary should be a consideration in each application.

2.0 DEFINITIONS

Appurtenant works are structures or materials built and maintained in connection with dams. These can be spillways, low-level outlet works and conduits.

Auxiliary spillway is a secondary spillway designed to operate only during large floods.

Cofferdam is a temporary structure enclosing all or part of the construction area so that construction can proceed in the dry.

Conduit is an enclosed channel used to convey flows through or under a dam.

Dam is any artificial barrier and its appurtenant works constructed for the purpose of holding water or any other fluid.

Department is the Department of Environmental Conservation (DEC).

Detention/Retention Basin is any structure that functions as a dam.

Earth Dam is made by compacting excavated earth obtained from a borrow area.

Energy Dissipator is a structure constructed in a waterway which reduces the energy of fast-flowing water.
**Flood Routing** is the computation which is used to evaluate the interrelated effects of the inflow hydrograph, reservoir storage and spillway discharge from the reservoir.

**Freeboard** is the vertical distance between the design high water level and the top of the dam.

**Gravity Dam** is constructed of concrete and/or masonry and/or laid-up stone that relies upon its weight for stability.

**Height** is the vertical dimension from the downstream toe of the dam at its lowest point to the top of the dam.

**Low-Level Outlet** is an opening at a low level used to drain or lower the water.

**Major Size Dam** is at least 25 feet high and holds at least 15 acre feet of water or is at least 6 feet high and holds at least 50 acre feet of water.

**Maximum Impoundment Capacity** is the volume of water held when the water surface is at the top of the dam.

**Probable Maximum Flood** (PMF) is the flood that can be expected from the severest combination of critical meteorologic and hydrologic conditions possible for the particular region. It is the flow resulting from the PMP.

**Probable Maximum Precipitation** (PMP) is the maximum amount of precipitation that can be expected over a drainage basin.

**Seepage Collar** is built around the outside of a pipe or conduit under an embankment dam to lengthen the seepage path along the outer surface of the conduit.

**Service Spillway** is the principal or first-used spillway during flood flows.

**Service Spillway Design Flood** (SSDF) is the flow discharged through the service spillway.

**Spillway** is a structure which discharges flows.

**Spillway Design Flood** (SDF) is the largest flow that a given project is designed to pass safely.

**Toe of Dam** is the junction of the downstream face of a dam and the natural ground surface, also referred to as downstream toe. For an earth dam the junction of the upstream face with the ground surface is called the upstream toe.
3.0 HAZARD CLASSIFICATION

3.1 General

The height of the dam, its maximum impoundment capacity, the physical characteristics of the dam site and the location of downstream facilities should be assessed to determine the appropriate hazard classification. Applications should include the design engineer's description of downstream conditions and his judgment of potential downstream hazards presented in the form of a letter designation and a written description.

3.2 Letter Designation

Class "A": dam failure will damage nothing more than isolated farm buildings, undeveloped lands or township or country roads.

Class "B": dam failure can damage homes, main highways, minor railroads, or interrupt use or service of relatively important public utilities.

Class "C": dam failure can cause loss of life, serious damage to homes, industrial or commercial buildings, important public utilities, main highways, and railroads.

3.3 Written Description

The written description is an elaboration of the letter designation. It includes descriptions of the effect upon human life, residences, buildings, roads and highways, utilities and other facilities if the dam should fail.

4.0 DESIGN AND CONSTRUCTION DOCUMENTS

4.1 Engineer Qualifications

The design, preparation of construction plans, estimates and specifications and supervision of the construction, reconstruction or repair of all structures must be done under the direction of a professional engineer licensed to practice in New York State. (See References 1 and 7).

4.2 Design Report

A design report, submitted with the application, should include an evaluation of the foundation conditions, the hydrologic and hydraulic design and a structural stability analysis of the dam. The report should include calculations and be sufficiently detailed to accurately define the final design and proposed work as represented on the construction plans. Any deviations from the guidelines should be fully explained.
4.3 Construction Plans

Construction plans should be sufficiently detailed for department evaluation of the safety aspects of the dam. The cover sheet should include a vicinity map showing the location of the dam. The size of the plans should be not less than 18 x 24 inches and no more than 30 x 48 inches. As-built plans of the project are required upon completion of construction.

4.4 Construction Inspection

The dam's performance will largely be controlled by the care and thoroughness exercised during its construction. Undisclosed subsurface conditions may be encountered which may materially affect the design of the dam. To ensure a safe design, the designer must be able to confirm design assumptions and revise the dam design if unanticipated conditions are encountered. Construction inspection is required in order to ensure that the construction work complies with the plans and specifications and meets standards of good workmanship. Therefore, construction inspection of a dam is required by a licensed professional engineer to monitor and evaluate conditions as they are disclosed and to observe material placement and workmanship as construction progresses.

The engineer involved in the construction of the dam work will be required to submit a periodic construction report to the Department covering the critical inspection activities for the dam's construction/reconstruction. Prior to permit issuance the applicant shall submit, for review and approval, a proposed schedule of construction inspection activities to be performed by the applicant's engineer. Upon permit issuance, the approved schedule shall be part of the required work.

4.5 Specifications

Materials specifications will be required for items incorporated in the dam project. Materials specifications including format found acceptable are those issued by the following agencies and organizations.

State: New York State Department of Transportation

Federal: COE - Corps of Engineers
        SCS - Soil Conservation Service

Industry: ASTM - American Society for Testing and Materials
        ACI - American Concrete Institute
        AWWA - American Water Works Association
        CSI - Construction Specifications Institute
5.0 HYDROLOGIC CRITERIA

5.1 Hydrologic Design Criteria

A table of hydrologic design criteria giving the spillway design flood, the service spillway design flood and minimum freeboards for various hazard classifications can be found in Table 1.

5.2 Design Flood

The National Weather Service has published data for estimating hypothetical storms ranging from the frequency-based storm to the Probable Maximum Precipitation event. For the frequency-based storms Technical Paper TP-40 (Ref 17) and TP-49 (Ref 18) will be used to determine rainfall. For the Probable Maximum Precipitation event, Hydrometeorological Report HMR-51 (Ref 16) will be used.

When using the above mentioned TP's and HMR's, the minimum storm duration will be six hours. For large drainage areas in which the time of concentration exceeds six hours, the precipitation amounts must be increased by the applicable duration adjustment.

The Soil Conservation Service (SCS) has developed Technical Release 55 (TR-55) "Urban Hydrology for Small Watersheds". TR-55 presents simplified procedures for estimating runoff and peak discharge and is an acceptable procedure for designing spillways for small watersheds. In developing TR-55 the SCS uses a storm period of 24 hours for the synthetic rainfall distribution.

Although the "rational method" (Q=CIA) is used for estimating design flows for storm drains and road culverts, it normally is not an acceptable method for determining peak discharge for the design of a dam spillway. The rational method should not be used for watershed areas larger than 200 acres because of its inaccuracy above that range. The greatest weakness of the "rational method" for predicting peak discharges lies in the difficulty of estimating the duration of storms that will produce peak flow. The greatest probability for error, both as to magnitude and understanding relates to the term "intensity" or "rate of rainfall". Although the units are inches per hour, the term does not mean the total inches of rain falling in a period of one hour. "Intensity" should be related to the time of concentration. "Intensities" would be higher for storms of short duration and would be lower for storms of longer duration.

Table I indicates that the appropriate Spillway Design Flood will be a percentage of the 100 year flood or the PMF. Therefore, in order to correctly determine the peak flow, the rainfall values used will be for the 100 year flood or the PMF and the appropriate peak discharge will be computed. After the peak discharge has been found, this value will then be multiplied by the appropriate percentages. For example a small dam in the Class "B" hazard category will have the discharge based on the
rainfall from a 100 year flood and this discharge will then be multiplied by 2.25 to obtain the peak discharge. The percentages should be applied to the discharge values in the final step of the calculations. It is incorrect to apply the percentages to the rainfall values.

5.3 Existing Dams - Design Flood

Existing dams that are being rehabilitated should have adequate spillway capacity to pass the following floods without overtopping:

<table>
<thead>
<tr>
<th>Hazard Classification</th>
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<tr>
<td>A</td>
<td>100 year</td>
</tr>
<tr>
<td>B</td>
<td>150% of 100 year</td>
</tr>
<tr>
<td>C</td>
<td>50% of PMF</td>
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The Service Spillway Design Flood (SSDF) for existing dams is the same as shown for the new dams on Table 1.
TABLE 1 - NEW DAMS

HYDROLOGIC DESIGN CRITERIA TABLE

<table>
<thead>
<tr>
<th>HAZARD CLASSIFICATION</th>
<th>SIZE DAM</th>
<th>SPILLWAY DESIGN FLOOD (SDF)</th>
<th>SERVICE SPILLWAY DESIGN FLOOD (SSDF)</th>
<th>MINIMUM FREEBOARD (FT.)</th>
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<tbody>
<tr>
<td>&quot;A&quot; SMALL</td>
<td>100 year</td>
<td>5 year</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>&quot;A&quot; LARGE</td>
<td>150% of 100 yr.</td>
<td>10 year</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>&quot;B&quot; SMALL</td>
<td>225% of 100 yr.</td>
<td>25 year</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>&quot;B&quot; LARGE</td>
<td>40% of PMF</td>
<td>50 year</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>&quot;C&quot; SMALL</td>
<td>50% of PMF</td>
<td>25 year</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>&quot;C&quot; LARGE</td>
<td>PMF</td>
<td>100 year</td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

*SMALL

Height of dam less than 40 feet. Storage at normal water surface less than 1000 acre feet.

*LARGE

Height at dam equal to or greater than 40 feet. Storage at normal water surface equal to or greater than 1000 acre feet.

NOTE:

Size classification will be determined by either storage or height, whichever gives the larger size category.
6.0 HYDRAULICS OF SPILLWAYS

6.1 Spillways

Spillways protect the dam from overtopping. Consideration must be given to dams and reservoirs upstream of the dam in question when designing the spillway. A dam should be provided with either a single spillway or a service spillway-auxiliary spillway combination.

6.2 Single Spillway

For a single spillway, the structure should have the capacity and the durability to handle sustained flows as well as extreme floods and be non-erodible and of a permanent-type construction. Free overall spillways, ogee spillways, drop inlet or morning glory spillways, and chute spillways are common types. An earth or grass-lined spillway is not durable under sustained flow and should not be used as a single spillway.

6.3 Criteria for a single spillway are as follows:

6.3.1 Sufficient spillway capacity should be provided to safely pass the spillway design flood with flood routing through the reservoir. (See Table 1 for spillway design flood).

6.3.2 Assuming no inflow, the spillway should have sufficient discharge capacity to evacuate 75% of the storage between the maximum design high water and the spillway crest within 48 hours.

6.3.3 The spillway will have an energy dissipater at its terminus.

6.3.4 A drop inlet or morning glory spillway, as a single spillway, is only acceptable on a Hazard Class "A" structure with a drainage area of less than 50 acres. In this case, sufficient storage capacity should be provided between the spillway crest and top of dam to contain 150% of the entire spillway design flood runoff volume.

6.4 Service Spillway - Auxiliary Spillway Combination:

In the case of the service spillway - auxiliary spillway combination, the service spillway discharges normal flows and the more frequent floods, while the auxiliary spillway functions only during extreme floods.

Service spillways must be durable under conditions of sustained flows; whereas auxiliary spillways do not. Service spillways should have sufficient capacity to pass frequent floods and thus reduce the frequency of use of the auxiliary spillway. The service spillway usually does not have sufficient capacity to pass the entire spillway design flood. Drop inlet or morning glory spillways are common types of service spillways. This type of structure will consist of a vertical inlet riser connected to a service spillway conduit with an energy
dissipator at the outlet. An auxiliary spillway is capable of handling high but short duration flows. It may be an excavated grass-lined channel if the designer is able to limit velocities to the non-erodible range for grass. It cannot carry prolonged flows because of eventual deterioration of the grass linings. For spillways which will be required to discharge flows at a high velocity, a more permanent type of material such as concrete will be required. An auxiliary spillway may be located adjacent to a dam abutment or anywhere around the rim of the reservoir. It should be located sufficiently apart from the dam to prevent erosion of any embankment materials. A spillway over the dam is not acceptable. It may either discharge back into the natural watercourse below the dam, or so long as a flood hazard is not created, into a watercourse within an adjacent drainage basin.

6.5 Criteria for an auxiliary spillway-service spillway combination are as follows:

6.5.1 Sufficient service spillway capacity should be provided to safely pass the service spillway design flood with flood routing through the reservoir. (See Table 1 for service spillway design flood).

6.5.2 The service spillway normally should be provided with an energy dissipater at its outlet end.

6.5.3 The auxiliary spillway crest must be placed at or above the service spillway design high water, and not less than 1 foot above the service spillway crest.

6.5.4 The auxiliary spillway-service spillway combination must provide sufficient discharge capacity to safely pass the spillway design flood with flood routing through the reservoir (See Table 1 for spillway design flood).

6.5.5 Assuming no inflow, the auxiliary spillway-service spillway combination should have sufficient capacity to evacuate the storage between the maximum design high water and the auxiliary spillway crest within 12 hours.

6.5.6 Assuming no inflow, the service spillway should have sufficient capacity to evacuate 75% of the storage between the auxiliary spillway crest and the service spillway crest within 7 days.

6.5.7 Auxiliary spillways shall not be placed on fill.

6.5.8 Velocities in auxiliary spillways should not exceed the maximum permissible velocities (non-erodible velocities) of the spillway materials.
6.5.9 If an auxiliary spillway is located near an embankment, it should be located so as not to endanger the stability of the embankment. The following criteria will help guard against damage to the embankment:

a. Discharge leaving the exit channel should be directed away from the embankment and should be returned to a natural watercourse far enough downstream as to have no erosive effect on the embankment toe.

b. The spillway exit channel, from the spillway crest to a section beyond the downstream toe of dam, should be uniform in cross-section, contain no bends, and be longitudinally perpendicular to the spillway crest. Curvature may be introduced below the toe of dam if it is certain that the flowing water will not impinge on the toe of dam.

6.0 A FLASHBOARD POLICY

Background

Flashboards are used to raise the water surface of an impoundment. However, the installation of flashboards along the crest of a spillway may permanently reduce the size of the spillway opening. Our records indicate that in some instances the reduction of spillway capacity with the installation of flashboards has resulted in overtopping and subsequent dam failure. Two examples are the Tillson Lake Dam (#1942420) in Ulster County and the Lake Algonquin Dam (#171-2700) in Hamilton County.

In 1939 flashboards were placed across the spillway of the 40 foot high Tillson Lake Dam in such a manner as to greatly reduce the spillway opening. Storm flow caused dam overtopping which eroded the earth slope in front of the 100 foot wide, 30 foot high concrete core wall. Failure of the core wall resulted in a tremendous amount of erosion to farm land, loss of farm machinery, chickens, several local bridges and basement flooding. The dam was rebuilt and failed in 1955 because flashboards were again in place and did not fail during storm flow.

In 1949 the Lake Algonquin Dam failed because flashboards were not removed for the winter. A January storm caused overtopping and subsequent dam failure at the right abutment. The dam failure resulted in the loss of a home, several farm buildings and a road.

When wood flashboards are installed properly they will be
supported by steel pins. These steel pins will be designed to fail when the depth of flow over the top of the flashboards reaches a certain level. Critical to the design of the flashboard system are the diameter of the steel pin, the ultimate strength of the steel and the spacing of the pins. In very few cases is the Consulting Engineer or Contractor who designed the flashboards able to provide sufficient quality control to ascertain that the as-built condition is similar to the design proposal.

Many field maintenance personnel do not understand the need for flashboards to fail when the depth of flow over the flashboards reaches a certain level. Therefore, there is a tendency to insert the flashboards in such a manner so that they will never fail, thus permanently reducing spillway capacity and increasing the possibility of dam failure by overtopping. This is what nearly happened at the Gore Mountain Dam at North Creek. During the period of 1977-1980 DEC operations personnel installed wide flange beams to support the wood flashboards. The approved design for the flashboard supports were one inch diameter steel pins. However, operations personnel decided they would have less maintenance problems if they permanently secured the wood flashboards between the six inch wide flange beams. Under this support the flashboards would never fail.

Around February 15, 1981 a sudden thaw and rain caused the water level at Gore Mountain Dam to rise within eight inches of the top of dam. This level was about two feet, four inches over the top of the flashboards. The extra sturdy wide flange beam support system precluded any chance of flashboard failure. Fortunately this abnormally high level was reported to the DEC by a local resident while he was snowmobiling. During the fall of 1981, DEC revised the flashboard support system so that the flashboards were properly supported by one inch diameter steel pins and the steel pins would fail in bending when the depth of flow over the top of the flashboards reached one foot.

For the foregoing reasons the Dam Safety Section has developed the following policy regarding the installation of flashboards on dams.

New Dams

Flashboards shall not be installed on any new dams. The dam owner or hydroelectric developer shall determine the normal pool elevation for the proposed impoundment and provide a permanently fixed spillway crest at the selected elevation. If pool elevation fluctuations are desired, they should be achieved by means of adequately sized gates, drains, siphons or other acceptable methods.
Existing Dams

A permanently fixed spillway crest is the preferred method of establishing normal pool elevation.

The installation or continued use of flashboards on existing dams will be considered on a case by case basis. Flashboards on existing dams will only be acceptable if the dam is able to satisfy the hydraulic and structural stability criteria contained in the Guidelines for Design of Dams. If the flashboards are designed to fail in order to satisfy either criterion, detailed failure calculations must be submitted for Department review and approval. The maximum pool elevation the flashboards are designed to fail at shall be the lower of:

1. Two times the height of the flashboards measured from the bottom of the flashboards, or

2. Two times the freeboard specified in Table 1 of these Guidelines, for a dam of the pertinent size and hazard classification, measured downward from the top of dam.

The maximum pool elevation that would be reached under Spillway Design Flood conditions, without the flashboards failing, shall also be determined.

Flashboards shall be installed, operated and maintained as intended in their design and in accordance with the terms and/or conditions of any permits or approvals. The approved flashboard configuration (pin spacing, pin size, board height, board size, etc.) shall not be modified without prior Department approval.
7.0 OUTLET WORKS AND CONDUITS

7.1 Outlet Works

A low-level outlet conduit or drain is required for emptying or lowering the water in case of emergency; for inspection and maintenance of the dam, reservoir, and appurtenances; and for releasing waters to meet downstream water requirements. The outlet conduit may be an independent pipe or it may be connected to the service spillway conduit. The low level drain is required to have sufficient capacity to discharge 90% of the storage below the lowest spillway crest within 14 days, assuming no inflow into the reservoir.

7.2 Control

Outlet conduits shall have an upstream control device (gate or valve) capable of controlling the discharge for all ranges of flow.

7.3 Conduits

Only two types of conduits are permitted on Hazard Class "B" and "C" structures; precast reinforced concrete pipe and cast-in-place reinforced concrete.

On Hazard Class "A" structures, welded steel pipe or corrugated metal pipe may be used providing the depth of fill over the pipe does not exceed 15 feet and the pipe diameter does not exceed 24 inches.

All outlet conduits shall be designed for internal pressure equal to the full reservoir head and for the superimposed embankment loads, acting separately.

The minimum size diameter conduit used as the barrel of a drop inlet service spillway shall be 12 inches.

The joints of all pipe conduits shall be made watertight.

Any pipe or conduit passing through an embankment shall have features constructed into the embankment whereby seepage occurring along the pipe or conduit is collected and safely conveyed to the downstream toe of the embankment. This can be accomplished by using a properly designed and constructed filter and drainage diaphragm. The filter and drainage diaphragm will be required unless it can be shown that antiseep collars will adequately serve the purpose.

Antiseep collars will not be permitted for dams with a height in excess of 20 feet. If antiseep, collars are used in lieu of a
drainage diaphragm, they shall have a watertight connection to the pipe. Collar material shall be compatible with pipe materials. The antiseep collars shall increase the seepage path along the pipe by at least 15%.

A means of dissipating energy shall be provided at the outlet end of all conduits 12 inches or more in diameter. If a plunge pool is used, the conduit should be cantilevered 8 feet over a concrete, steel or treated timber support located near or at the downstream toe of the embankment. The plunge pool should be riprap-lined if a conduit 18 inches or more in diameter is used. The foregoing may apply to smaller pipes if the embankment's downstream slope is steep and the soil erodible.

8.0 GEOTECHNICAL INVESTIGATION

8.1 Foundations

8.1.1 Subsurface explorations (drill holes, test pits and/or auger holes) should be located along the centerline of the dam, at the proposed service and auxiliary spillway locations, and in other critical areas. The depth of the subsurface explorations should be sufficient to locate and determine the extent and properties of all soil and rock strata that could affect the performance of the dam, the reservoir and appurtenant structures. Referring to information such as geologic bulletins, soil survey maps, groundwater resources bulletins, etc., may aid the designer in determining the scope of the exploration program needed and interpreting the results of the program. For even the smallest low hazard dams, at least three explorations should be made along the centerline of the dam, one in the deepest part of the depression across which the dam will be built and one on each side. At least one exploration should be made at the proposed auxiliary spillway location. For small low-hazard dams, to be built on a foundation known from the geology of the area to be essentially incompressible and impervious to a great depth, the minimum depth of explorations should be 5 feet unless bedrock is encountered above this depth. In other cases the minimum depth of explorations should be 10 feet, with one or more borings extending to a depth equal to the proposed height of the dam. If it is proposed to excavate in the reservoir area, the possibility of exposing pervious foundation layers should be investigated by explorations or a review of the geology of the area. If rock is encountered in explorations, acceptable procedures, such as coring, test pits, or geologic information, should be used to verify whether or not it is bedrock.

8.1.2 Sufficient subsurface explorations should be made to verify the suitability of encountered rock for use as a foundation
and/or construction material. Testing of the rock materials shall ascertain its strength, compressibility, and resistance to degradation, and its ability to safely withstand the loads expected to be imposed upon it by the proposed project.

8.1.3 Soils encountered in explorations should be described accurately and preferably classified in accordance with the Unified Soil Classification System.

8.1.4 For Hazard Class "C" dams, appropriate field and/or laboratory tests should be performed in order to aid in evaluating the strength, compressibility, permeability, and erosion resistance of the foundation soils. Also, appropriate laboratory tests should be performed on samples of the proposed embankment materials in order to ascertain their suitability for use in the dam. Field and/or laboratory tests may be required also for dams of lower hazard classification in the case of critical foundation strength or permeability conditions.

8.1.5 Stability of the foundation under all operating conditions should be evaluated.

8.1.6 Settlement of the dam and appurtenant works should be evaluated and provisions made in the design to counteract the effects of any anticipated settlements.

8.1.7 Whenever feasible, seepage under the dam should be controlled by means of a complete cutoff trench extending through all pervious foundation soils into a relatively impervious soil layer. If the dam is to be built on an impervious foundation, the cutoff or key trench should be excavated to a depth of at least 3 feet into the foundation soils and backfilled with compacted embankment material. Where the final depth of cutoff cannot be established with certainty during design, a note should appear on the plans stating that the final depth of the cutoff trench will be determined by the engineer during the time of construction. Backfilling of the cutoff or key trench should be performed in the dry, unless special construction procedures are used. The bottom width of the trench should be at least 8 feet and should be increased in the case of dams more than 20 feet high. The widths of complete cutoffs may be made considerably less if the cutoff is extended vertically a minimum distance of 4 feet into impervious material. In the case of a cutoff or key trench extending to bedrock, the trench does not have to extend into rock. However, all shattered and disintegrated rock should be removed and surface fissures filled with cement grout. The need for pressure grouting rock foundations should be evaluated and, if necessary, adequately provided for.
8.2 Borrow Sources for Embankment Materials

Sufficient subsurface explorations should be made in borrow areas to verify the suitability and availability of an adequate supply of borrow materials. Logs of explorations should be included for review with the plans and specifications. Exposure of pervious soils and fissured rock below normal water surface of the proposed pond, at borrow areas located in or connected to the reservoir area, should be avoided.

If pervious soils or fissured rock conditions are encountered during borrow operations these exposed areas should be sealed with a sufficient thickness of compacted impervious material. In no case should this seal be less than two feet thick and consideration should be given to utilizing a greater thickness where site conditions and hazard classifications dictate.

Borrow areas should be located with due consideration to the future safety of the dam and should be shown on the plans. In general, no borrow should be taken within a distance measured from the upstream toe of the dam equal to twice the height of the dam or 25 feet, whichever is greater.

9.0 EARTH DAMS

9.1 Geometry

9.1.1 The downstream slope of earth dams without seepage control measures should be no steeper than 1 vertical on 3 horizontal. If seepage control measures are provided, the downstream slope should be no steeper than 1 vertical on 2 horizontal.

9.1.2 The upstream slope of earth dams should be no steeper than 1 vertical on 3 horizontal.

9.1.3 The side slopes of homogenous earth dams may have to be made flatter based on the results of design analyses or if the embankment material consists of fine grained plastic soils such as CL, MH or CH soils as described by the Unified Soil Classification System.

9.1.4 The minimum allowable top width (W) of the embankment shall be the greater dimension of 10 feet or W, as calculated by the following formula:

\[ W = 0.2H + 7; \text{ where } H \text{ is the height of the embankment (in feet)} \]
9.1.5 The top of the dam should be sloped to promote drainage and minimize surface infiltrations and should be cambered so that the design freeboard is maintained after post-construction settlement takes place.

9.2 Slope Stability

Where warranted and especially for new Hazard Class "C" dams, the department may require that slope stability analyses be provided for review. The method of analyses and appropriate factors of safety for the applicable loading conditions shall be as indicated by U. S. Army Corps of Engineers publications (latest edition) (Ref. 11).

Earth dams, in general, should have seepage control measures, such as interior drainage trenches, downstream pervious zones, or drainage blankets in order to keep the line of seepage from emerging on the downstream slope, and to control foundation seepage. Hazard Class "A" dams less than 20 feet in height and Hazard Class "B" dams less than 10 feet in height, if constructed on and of erosion-resistant materials, do not require special measures to control seepage.

In zoned embankments, consideration should be given to the relative permeability and gradation of embankment materials. No particle greater in size than six inches in maximum dimension should be allowed to be placed in the impervious zone of the dam.

9.3 Compaction Control and Specifications

Before compaction begins, the embankment material should be spread in lifts or layers having a thickness appropriate to the type of compaction equipment used. The maximum permissible layer thickness should be specified in the plans or specifications.

Specifications should require that the ground surface under the proposed dam be stripped of all vegetation, organic and otherwise objectionable materials. After stripping, the earth foundation should be moistened, if dry, and be compacted before placement of the first layer of embankment material. Inclusion of vegetation, organic material, or frozen soil in the embankment, as well as placing of embankment material on a frozen surface is prohibited and should be so stated in the specifications.

For all dams, compaction shall be accomplished by appropriate equipment designed specifically for compaction. The type of compaction equipment should be specified in the plans or specifications.
The degree of compaction should be specified either as a minimum number of complete coverages of each layer by the compaction equipment or, in the case of higher or more critical dams, based on standard ASTM test methods.

When the degree of compaction is specified as a number of complete coverages or passes, the final number of passes required shall be determined by the engineer during construction.

In order to insure that the embankment material is compacted at an appropriate moisture content, a method of moisture content control should be specified. For Hazard Class "A" dams less than 20 feet high, the moisture content may be controlled visually by a qualified inspector. Hand tamping should be permitted only in bedding pipes passing through the dam. All other compaction adjacent to structures should be accomplished by means of manually directed power tampers.

Backfill around conduits should be placed in layers not thicker than 4 inches before compaction with particle size limited to 3 inches in greatest dimension and compacted to a density equal to that of the adjacent portion of the dam embankment regardless of compaction equipment used.

Care should be exercised in placing and compacting fill adjacent to structures to allow the structures to assume the loads from the fill gradually and uniformly. Fill adjacent to structures shall be increased at approximately the same rate on all sides of the structures.

The engineer in charge of construction is required to provide thorough and continuous testing to insure that the specified density is achieved.

9.4 VEGETATION CONTROL - TREES AND BRUSH

9.4.1 Trees and Brush

Trees and brush are not permitted on earth dams because:

a. Extensive root systems can provide seepage paths for water.

b. Trees that blow down or fall over can leave large holes in the embankment surface that will weaken the embankment and can lead to increased erosion.
c. Brush obscures the surface limiting visual inspection, provides a haven for burrowing animals and retards growth for grass vegetation. Stumps of cut trees should be removed so grass vegetation can be established and the surface mowed. Stumps should be removed either by pulling or with machines that grind them down. All woody material should be removed to about 6 inches below the ground surface. The cavity should be filled with well compacted soil and grass vegetation established.

9.4.2 Grass Vegetation

Grass vegetation is an effective and inexpensive way to prevent erosion of embankment surfaces. It also enhances the appearance of the dam and provides a surface that can be easily inspected.

10.0 STRUCTURAL STABILITY CRITERIA FOR GRAVITY DAMS

10.1 Application

These guidelines are to be used for the structural stability analysis of concrete and/or masonry sections which form the spillway or non-overflow section of gravity dams.

These guidelines are based on the "Gravity Method of Stress and Stability Analysis" as indicated in Reference 13.

If the gravity dam has keyed or grouted transverse contraction joints, then the "Trial-Load Twist Method of Analysis" (Reference 13) may be used for the stability analysis.

Elastic techniques, such as the finite element method, may be used to investigate areas of maximum stress in the gravity dam or the foundation. However, the finite element method will only be permitted as a supplement to the Gravity Method. The Gravity Method will be required for the investigation of sliding and overturning of the structure.

10.2 Non-Gravity Dams

For non-gravity structures such as arch dams, the designer is required to present calculations based on appropriate elastic techniques as approved by the Dam Safety Section.
10.3 Loads

Loads to be considered in stability analyses are those due to: external water pressure, internal water pressure (pore pressure or uplift) in the dam and foundation, silt pressure, ice pressure, earthquake, weight of the structure.

10.4 Uplift

Hydrostatic uplift pressure from reservoir water and tailwater act on the dam. The distribution of pressure through a section of the dam is assumed to vary linearly from full hydrostatic head at the upstream face of the dam to tailwater pressure at the downstream face or zero if there is no tailwater. Reduction in the uplift pressures might be allowed in the following instances:

10.4.1 When foundation drains are in place. The efficiency of the drains will have to be verified through piezometer readings.

10.4.2 When a detailed flow net analysis has been performed and indicates that a reduction in uplift pressures is appropriate. Any reduction of pressure of more than 20% must be verified by borings and piezometer readings.

10.4.3 When a sufficient number of borings have been progressed and piezometer readings support the fact that actual uplift pressures are less than the theoretical uplift pressures.

10.5 Loading Conditions

Loading Conditions to be analyzed.

Case 1 - Normal loading condition; water surface at normal reservoir level.

Case 2 - Normal loading condition; water surface at normal reservoir level plus an ice load of 5,000 pounds per linear foot, where ice load is applicable. Dams located in more northerly climates, may require a greater ice load.

Case 3 - Design loading condition; water surface at spillway design flood level.
Case 3A - Maximum hydrostatic loading condition; maximum differential head between headwater and tailwater levels as determined by storms smaller in magnitude than the spillway design flood. This loading condition will only be considered when the is submerged under Case 3 loading condition.

Case 4 - Seismic loading condition; water surface at normal reservoir level plus a seismic coefficient applicable to the location.

10.6 Stability Analysis for New Dams

10.6.1 Field Investigation

Subsurface investigations should be conducted for new dams. Borings should be made along the axis of the dam to determine the depth to bedrock as well as the character of the rock and soils under the dam. The number and depth of holes required should be determined by the design engineer based on the complexity of geological conditions. The depth of holes should be at least equal to the height of the dam. Soil samples and rock cores should be collected to permit laboratory testing. The values of cohesion and internal friction of the foundation material should be determined by laboratory testing.

On proposed sites where the foundation bedrock is exposed, the requirements for borings may be waived in some cases. An engineering geologist's professional opinion of the rock quality and the acceptability of the design assumptions will be required in those cases.

10.6.2 Overturning

The resultant force from an overturning analysis should be in the middle third of the base for all loading conditions, except for the seismic analysis (Case 4), where the resultant shall fall within the limits of the base.

10.6.3 Cracking

The resultant force falling outside the middle third of the base and its resulting tension cracks will not be accepted in the design of new dams, except for the seismic loading condition (Case 4).
10.6.4 Sliding

Sliding safety factors may be computed using the Shear-Friction method of analysis when shear values are based on either the results of laboratory testing or an engineering geologist's professional opinion. When the Shear-Friction method is used, the structure should have a minimum safety factor of 2.0 for all loading conditions except for Case 4 (seismic loading) where the minimum acceptable sliding safety factor shall be 1.5.

Designs which are not based on laboratory testing or an engineering geologist's professional opinion must be analyzed using the Friction Factor of Safety. This analysis assumes that the value of shear or cohesion is zero. The minimum safety factor using this method should be 1.5 for all loading conditions except Case 4 where the minimum safety factor shall be 1.25.

10.7 Stability Analysis for Existing Dams

10.7.1 Field Investigations

Subsurface investigations should normally be conducted as part of a detailed structural stability investigation for an existing dam and should provide information regarding the materials of the dam and its foundation. The number and depth of holes required should be determined by the engineer based on the complexity of the composition of the dam and foundation. Samples should be collected and tested to determine the material properties. The program should also measure the uplift pressures at several locations along the base of the dam.

In cases where no subsurface investigations are conducted conservative assumptions regarding material properties and uplift pressures will be required.

10.7.2 Overturning

The resultant force from an overturning analysis should be in the middle third of the base for normal loading conditions (Case 1) and within the middle half of the base for the ice loading condition (Case 2) and the spillway design flood loading condition (Case 3). For the seismic loading condition (Case 4), the resultant force should fall within the limits of the base.
10.7.3 Cracking

If the overturning analysis indicates that the resultant force is outside the middle third, then tension exists at the heel of the dam which may result in the cracking of the concrete. For existing dams cracking will be permitted for all loading conditions except the normal loading condition (Case 1). If the criteria specified above in Overturning for the location of the resultant force are not satisfied, further study and/or remedial work will be required. The Bureau of Reclamation’s Cracked Section Method of analysis is acceptable for investigating the stability of the dam for the above mentioned loading conditions. When the Cracked Section Method of analysis is used, the criteria for the minimum sliding factor of safety will have to be satisfied.

10.7.4 Sliding

Sliding safety factors may be computed using the Shear-Friction method of analysis when shear values are based on the results of laboratory testing of samples from subsurface investigations. When the Shear-Friction method is used, the structure should have a minimum safety factor of 2.0 for Case 1 and Case 2; a value of 1.5 for Case 3 and a value of 1.25 for Case 4.

If no subsurface explorations are performed, the sliding safety factors must be computed using the Friction Factor of Safety. The minimum safety factor using this method should be 1.5 for Case 1; a value of 1.25 for Case 2 and Case 3; and a value of 1.0 for Case 4.

11.0 EXISTING DAMS: REHABILITATION AND MODIFICATION

Additional data should be submitted for dam rehabilitations or dam modifications, including a report by a professional engineer describing the performance and maintenance history of the existing dam. In addition, all data regarding construction, such as existing subsurface explorations, construction materials used for the dam, and plans and specifications should be submitted. If this information is not available, the engineer should inspect and evaluate the structure as to its condition, performance, maintenance history and other information regarding foundation soils and existing conditions.

The engineer should also assess the safety and adequacy of the existing structure against those criteria for spillway capacity and structural stability, indicated in the appropriate sections of these guidelines.
Where a new embankment is to be constructed against an existing dam embankment, the existing slope shall be benched as the new fill is spread and compacted in layers as described in the plans and specifications. This benching is done to provide an interlock between the existing and new embankments. Benching shall not be done in the upstream-downstream direction.

All topsoil and sod shall be stripped from the surface of the existing embankment before placing new material within the area of reconstruction.

Remove or seal all existing drainage structures which are not to be operative in the proposed design, in order to prevent a plane of seepage from developing through the dam.

12.0 COFFERDAMS

A cofferdam in most cases is a temporary structure enclosing all or part of the construction area. The purpose of the cofferdam is to provide protection so that construction can proceed in the dry.

12.1 When using a cofferdam the following criteria must be met:

12.1.1 Flood Plain Management

A hydraulic analysis must be performed to determine the backwater effect of the cofferdam. A range of flood discharges up to and including the 100 year return frequency flood shall be evaluated to determine the potential flood damages to lands and improvements upstream of the cofferdam not owned or otherwise controlled by the applicant. The analysis shall focus on determining if the project meets the flood plain management criteria of 6NYCRR-Part 500, if applicable, or regulations adopted by the local jurisdiction for participation in the National Flood Insurance Program.

12.1.2 Dam Safety

The applicant will have to demonstrate that cofferdam failure will not adversely impact lives and property. The evaluation will focus on the potential for flooding, loss of life and damage to properties downstream of the cofferdam not owned or otherwise controlled by the applicant.
If cofferdam failure could adversely impact properties downstream of the cofferdam, not controlled by the applicant, or if the cofferdam failure could adversely impact lives, then more specific information regarding the geotechnical, structural and hydraulic aspects of the cofferdam design will be required. The determination by the department of the acceptability of the cofferdam design will be made on a case-by-case basis.

13.0 MISCELLANEOUS

The earth embankment, earth spillways, and all disturbed earth adjacent to the embankment or other appurtenances should be seeded, except where riprap or other slope protective materials are specified.

Where destructive wave action is expected, the upstream slope of the embankment should be protected with rock riprap or other suitable material for effective erosion control.

A trash rack designed to prevent debris from entering and obstructing flow in the conduit should be provided on the vertical riser for any drop inlet spillway.

An anti-vortex device is required on the vertical riser for any drop inlet spillway with riser diameter greater than 12 inches.

Instrumentation

1. Piezometers - All earth dams 40 feet high or higher shall have at least two piezometers on the downstream slope of the embankment to measure saturation levels and hydrostatic pressures. All concrete dams 40 feet or higher should have at least two piezometers along the crest of the dam.

2. Weirs - on all dams with toe drains, weirs are required at the downstream end of the drain. The weirs measure the amount of seepage water through the embankment. Measurements of the seepage should be documented and correlated with the reservoir surface elevation. See Reference 6, pages 55-56.

14.0 EMERGENCY ACTION PLAN

An emergency action plan (EAP) should be developed by the owner of a high hazard dam (Class "C").
A copy of this EAP is to be provided to the Dam Safety Section of the department during the initial permit review period for new dams and for existing dams, if a copy of the EAP has not been previously submitted. See Reference 6, pages 69-73.

15.0 APPROVAL TO FILL RESERVOIR OF A NEW DAM

Before any water can be impounded by the dam, the dam owner shall adhere to the following:

15.1 For all Hazard Class "C" and [major size] Hazard Class "B" dams.

Within two weeks after completion of dam construction the permittee shall notify the Regional Permit Administrator in writing by certified mail of its completion and shall include a notarized statement from the owner's engineer that the project has been completely constructed under his care and supervision in accordance with plans and specifications as approved by the department. Any changes in the construction of the dam from the approved plans will be reflected in the "As-Built" plans.

The department will inspect the completed dam with the owner's engineer. During the inspection, the owner's engineer will submit "As Built" drawings and other construction records for review, such as foundation data and geological features, properties of embankment and foundation materials, concrete properties and construction history. Upon review of the data and the determination of the adequacy of the structure the "Approval to Fill" letter will be issued, permitting the owner to store water.

15.2 For all Hazard Class "A" and [Below Major Size] Hazard Class "B" dams.

Within two weeks after completion of dam construction the permittee shall notify the Regional Permit Administrator in writing by certified mail of its completion and shall include a notarized statement from the owner's engineer stating that the project has been completely constructed under his care and supervision in accordance with plans and specifications as approved by the department. Any changes in the construction of the dam from the approved plans will be reflected in the "As-Built" plans that will be submitted to the Department.

No water shall be impounded for at least 15 days subsequent to the notification to the Regional Permit Administrator.
REFERENCES

1. New York State Environmental Conservation Law "Article 15-0503".


3. New York Code of Rules and Regulations (6NYCRR) "Part 673 - Dam Safety Regulations"

4. New York Code of Rules and Regulations (6NYCRR) "Part 500 - Flood Plain Development Permits"


7. New York State Education Law "Article 55".

8. Soil Conservation Service; U. S. Department of Agriculture SCS National Engineering Handbook; August, 1972 "Section 4 - Hydrology

Corps of Engineers; U. S. Army

9. Hydrologic Engineering Center
"HEC-1 Flood Hydrograph Package"; 1981

10. ETL 1110-2-256; June 1981
"Sliding Stability for Concrete Structures".

11. EM 1110-2-1902; April 1970
"Stability of Earth and Rock-Fill Dams"

Bureau of Reclamation; U. S. Department of the Interior


15. Hydrometeorological Report 33; April 1956 "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1000 Square Miles and Durations of 6, 12, 24 and 48 Hours"


17. Technical Paper 40; May 1961 "Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years"

18. Technical Paper 49; 1964 "Two-to-Ten-Day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States"
This document has been developed to provide Department staff with guidance on how to ensure compliance with statutory and regulatory requirements, including case law interpretations, and to provide consistent treatment of similar situations. This document may also be used by the public to gain technical guidance and insight regarding how the department staff may analyze an issue and factors in their consideration of particular facts and circumstances. This guidance document is not a fixed rule under the State Administrative Procedure Act section 102(2)(a)(l). Furthermore, nothing set forth herein prevents staff from varying from this guidance as the specific facts and circumstances may dictate, provided staff's actions comply with applicable statutory and regulatory requirements. This document does not create any enforceable rights for the benefit of any party.

Preliminary DRAFT

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I. Summary:

Title 6 of New York Rules and Regulations, Part 673.13 (“Part 673.13”) requires the preparation of an Engineering Assessment Report, which must be submitted to the New York State Department of Environmental Conservation (“Department”).

This policy provides guidance to dam owners and engineers on the preparation of, and DEC staff on the review of, Engineering Assessment Reports pursuant to Part 673.13.

II. Policy:

The life-cycle of a dam consists of several phases, starting with construction and initial filling and transitioning to alternating periods of normal operation and maintenance, repairs, and upgrades. This cycle continues until the dam is breached or removed, or fails. For a dam to continue to serve its intended function, it must be maintained. As conditions change over time, repairs and perhaps reconstruction and/or upgrade of the dam, for example increasing the spillway capacity, may become necessary.

A dam is a part of a dynamic system, with various forces continuously acting upon it, such as ice, flooding, earthquakes, erosion, animal burrowing, woody root penetration, and sediment accumulation. Downstream developments can affect the hazard class of a dam, upstream developments can change the way the watershed behaves during runoff events, and science and technology evolve to modify best practices and regulatory criteria over time.

The release of water stored by a dam in an uncontrolled manner represents a potential danger to downstream lives, property and the environment. As such, the dam owner must develop and implement a dam safety program. Part 673 requires that an owner’s dam safety program that is appropriate to the dam’s hazard classification. Those for Class C (High Hazard) or Class B (Intermediate Hazard) dams consist of periodic safety inspections and engineering assessments, along with an Inspection and Maintenance Plan (“I&M Plan”) and an Emergency Action Plan (“EAP”). An I&M Plan template is available on the Department’s web site. Requirements for the preparation of an EAP are described in the Department’s publication “DOW 3.1.3 – Emergency Action Plans for Dams”. Periodic safety inspections and engineering assessments are intended to provide an independent review of an existing structure and the owner’s dam safety program, identify any deficiencies or gaps in knowledge, and determine the steps and schedule necessary to correct the deficiencies.

When deficiencies are identified, the dam owner must categorize them either as issues that can be resolved through regular or enhanced maintenance, or whether repairs and/or upgrades are required. Conditions requiring additional or continued monitoring should also be identified. Maintenance is work involved in the routine or regular upkeep of a dam, and includes, for example, debris removal, mowing grass, cleaning trash racks, and exercising valves. Repairs or upgrades generally consist of more extensive or intrusive work, which if performed improperly could endanger the structure, and therefore must be performed under the supervision of a professional engineer (“PE”), in accordance with a formal design, and require a dam safety permit issued by the Department through its Division of Environmental Permits, in pursuant to Parts 608 and 621. Although maintenance does not require a Dam Safety permit, it could require other types of permits, such as a Construction Stormwater permit, from the DEC.
Safety inspections and engineering assessments include many of the components that would be required as part of a permit application for repair or upgrading of the dam. The difference is that regular inspections and assessments are an evaluation of the existing structure against current dam safety criteria, whereas the Engineering Design Report, plans and specifications required for a permit must evaluate the proposed repairs and/or upgrades to the structure. In either case, the dam and appurtenant structures should be considered as part of an integrated system, and must function together to safely fulfill their water impounding function.

III. Purpose and Background:

It is the purpose of this guidance to inform owners, engineers, and DEC staff regarding the procedures, content, and format for dam safety engineering assessment reports as required by 6NYCRR Part 673.

Part 673 requires owners of Hazard Class B (Intermediate Hazard) and Class C (High Hazard) dams, and, at the Department’s discretion, dams assigned a Condition Rating of Unsafe or Unsound, to perform an Engineering Assessment of their dam on a regular basis.

This guidance represents the professional judgment of the Department’s Dam Safety Section’s engineers. The guidance is applicable for the average dam in an average situation. Where unusual conditions exist, it is the duty of the dam owner’s engineer to highlight any deviation from the Department’s guidance and provide the specific engineering rationale for said deviation. Cost alone is not an acceptable rationale.

IV. Responsibility:

The dam safety program within the Bureau of Flood Protection and Dam Safety will interpret and maintain this policy.

V. Procedure:

The Engineering Assessment Report must, at a minimum, include the following:

1. Hazard classification evaluation
2. Complete Safety Inspection
3. Evaluation of the dam’s spillway capacity
4. Evaluation of the dam’s structural stability
5. Evaluate Outlet works (reservoir drain) capacity
6. Review of the dam’s Emergency Action Plan, and
7. Provide a conclusion as to whether the dam is in conformance with current dam regulations and safety guidance.

The tasks normally associated with performing a dam safety Engineering Assessment can be divided as follows:

A. File review
B. On-site Engineering Inspection and Investigation
C. Engineering review, calculations, and conclusions
D. Engineering Assessment Report Generation
E. File report with Department and retain a copy with owner’s records

The assessment should determine the condition of the dam relative to the appropriate safety criteria. It should identify deficiencies and recommend, as appropriate, remedial repairs, operational restrictions, monitoring, and/or modifications. The assessment should also identify any analyses and/or studies needed to assess and determine solutions to identified deficiencies.

The engineering assessment must be performed by a professional engineer registered to practice in New York State and possessing appropriate experience in evaluation of dams of type, size, and location to be assessed. The dam Engineering Assessment Report must be submitted to the Department in accordance with the schedule detailed in Part 673. The owner must retain a copy of the dam Engineering Assessment Report with their records of the dam.

A. Records Review

Perform a review of existing dam information. The engineer must analyze the dam’s design, construction, and operational records to become fully acquainted with the present physical features as well as construction and performance history of the dam.

An owner may have a recently performed engineering assessment of the dam. At the owner’s and engineer’s option, the engineer may review the report for applicability to current standards and safety criteria and adopt all or parts of past reports. If an engineer does accept the analysis in any previous report, the engineer must state that the report’s assumptions, analyses, or other accepted components have been reviewed and are acceptable to demonstrate compliance with selected criteria (as applicable). The engineer or owner may also choose to disregard previous assessments and perform a completely new assessment.

There may be multiple information sources, including, but not limited to, the following:

Owner’s Dam File:

The owner should have a file for the dam that might contain dam design information and various reports generated when the dam was designed or rebuilt; hydrology, hydraulics, geology, inspections, etc. Operational records, if available, may contain vital information that should be reviewed in detail. The review should include review of the existing I&M Plan, results of past inspections, and maintenance work completed and/or planned. Finally, this part of the review should include a review of the dam’s Emergency Action Plan, with particular attention to the inundation map. Part 673, effective August 19, 2010, requires the owner to retain pertinent records on a dam, and authorizes DEC to inspect those records.

Department’s Dam Safety File:

The Department maintains a file for most dams in the state. While the DEC file may contain similar information to that contained in the owner’s dam file, it can often provide supplementary information.
B. On-site Engineering Inspection and Investigation

The Engineer should perform at least two specific on-site activities; a hazard classification reconnaissance and a thorough dam safety inspection. Additional on-site investigations; i.e., soil borings, test pits, topographic and boundary surveys, etc., may be necessary dependent on what additional information is required to complete the engineering assessment. Interviews with maintenance personnel and other people familiar with the dam are also recommended.

Hazard Classification Reconnaissance

The dam’s hazard classification influences the regulatory and design standards for the dam and is therefore a critical component to the assessment. A dam’s hazard classification will typically dictate spillway capacity criteria, which in turn affects much of the remainder of the assessment, as well as the EAP requirements.

The first step in determining a dam’s hazard classification is to perform a review of the downstream area of the dam. Before beginning the field reconnaissance, the engineer should become familiar with the dam’s features and setting through a desktop review of the downstream area using readily accessible data such as USGS 7 ½ minute quadrangle maps, recent orthoimagery, and similar tools to determine potential downstream features that may be impacted by the dam’s failure flood wave. The engineer can then perform the downstream field investigation to verify the buildings, roads, railroad, environmentally sensitive areas, etc. that will be within the flood wave’s path. In most cases, field work will also be necessary to assess potential impacts and recommend a hazard classification.

The engineer should also review the local planning board’s records to identify if proposed downstream development may impact the dam’s future hazard classification. Draft planning documents will not impact the current hazard classification but may provide an indicator of future changes that could affect the classification and design standards.

The Engineering Assessment Report should include a written description of the hazard classification review, description of potential downstream impacts, and a recommended hazard classification in accordance with the hazard classification regulations at Part 673.5 and applicable NYS DEC guidance.

Dam Safety Inspection

The dam safety inspection is a comprehensive examination of the visible physical features of the dam and its appurtenant structures. The dam safety inspection requirements are presented in 6NYCRR Part 673.12(d). The visual inspection should comment on previously observed deficiencies, including the deficiencies’ progression or advancement and identification of continuing or new corrective actions, as necessary,
with recommendations and a schedule. Corrective actions and recommendations may be
defered until after the technical analysis.
All observations and unusual features should be recorded, regardless of how insignificant
they may seem. Photographs are a permanent record of the condition of the dam and
provide a means to compare dam conditions at different points in time. Photographs are a
required element of the Dam Safety Inspection Report.

A good source of information for conducting a dam safety inspection can be found in the
Department’s “An Owners Guidance Manual for the Inspection and Maintenance of
Dams in New York State” which can be found at
http://www.dec.ny.gov/lands/4991.html. Other references can be found on the Internet.

Underwater inspections may be required if the condition or design of underwater features
is not well known. If necessary, an underwater inspection should be conducted as part of
the Safety Inspection.

Other On-Site Investigations:

It may be necessary to conduct various investigations to verify assumptions that are used
in the Engineering Assessment Report, i.e. subsurface investigation to obtain data for the
dam’s stability assessment, or determining the source of potential seepage.

C. Engineering Review, Calculations, and Conclusions

Following completion of the records review and on-site investigations, the engineering
review can commence. The engineering review consists of:

1. Hazard Classification,
2. Hydrology Assessment,
3. Hydraulic Assessment,
4. Stability Assessment,
5. Conclusions and Recommendations.

Each of these tasks is described below.

1. Hazard Classification

Using information obtained during the on-site hazard classification reconnaissance and
other information; i.e., topographic maps, orthoimagery, etc. (and following the
Department hazard classification guidance) a hazard classification for the dam needs to
be determined. If the dam is already classified as a Class C-high hazard dam, and there is
no disagreement that there will be probable loss of life if the dam were to fail, it is not
necessary to spend a great deal of effort on this portion of the assessment. If the
assessment results in the dam’s hazard classification changing, all documents supporting
the hazard classification change must be included in the report. An electronic copy of all
models used, not just the model’s results, must be made a permanent part of the
engineering assessment.

2. Hydrology Assessment
Given a dam’s hazard classification, the inflow design storm can be determined, see Section 5.3 and Table 1 of the Department’s “Guidelines for the Design of Dams, Revised January 1989 (‘Guidelines’).” If existing dam documents contain a viable hydrologic study, that hydrologic study can be utilized. All assumptions and analyses used in the study need to be independently verified and all models employed need to include the latest hydrologic criteria applicable to the field of dam safety engineering, many of which are reflected in the Guidelines.

Note: As stated in the 1989 Guidelines, HMR-33 has been replaced by HMR-51 and 52, which are the applicable models for determining the Probable Maximum Flood in New York. If the dam is a high hazard dam and the hydrology model employed to determine the Probable Maximum Flood was HMR-33, the Probable Maximum Flood should now be determined using HMR-51/52. HMR-33 is not accepted.

The Department does not have a preferred hydrology model for determining the inflow design storm, but any model used should be appropriate for the geographic and hydrologic setting of the dam being studied. The Engineering Assessment Report needs to include both the input and output pages for the model and should include an electronic copy of the model for the Department’s review.

3. Hydraulic Assessment

If the dam’s record contains a viable hydraulic assessment that uses the appropriate inflow design flood, that hydraulic study may be utilized. All assumptions and analyses used in previous reports must be verified by the engineer performing the new assessment, if the engineer wishes to rely on them. If the inflow design storm is different than the previous studies, a new hydraulic analysis will be necessary.

The design criteria for the hydraulics study can be found in Section 6.0 of the “Guidelines”. If a computer model is used to perform the hydraulic assessment, the input and output printout must be contained within the assessment and an electronic copy of the model must be provided to the department for its review.

4. Stability Assessment

If the dam’s record contains a viable stability assessment, that stability study may be utilized. Even if previous loading assumptions are no longer valid, other parts of a previous stability assessment may be utilized if appropriate. Again, all assumptions and analyses used in previous reports must be verified by the engineer conducting the new assessment.

The design criteria for the stability study can be found in Section 10.0 of the “Guidelines”. If a computer model is used to perform the stability assessment, the model’s name, model version, and the input and output printout should be placed in the assessment and an electronic copy of the model must be included within the assessment and an electronic copy of the model must be provided to the department for its review.

The stability analysis depends on the existing subsurface geology and often requires a geotechnical investigation. Previous geotechnical investigations may be available from which to gather soil or rock parameters. The need for additional or new geotechnical investigations may also be indicated. The engineer performing the Engineering
Assessment must judge whether existing information is sufficiently reliable to determine the dam’s stability. If there is visual indication that the dam may be in distress because of stability reasons, additional geotechnical investigations may be needed.

5. Conclusions and Recommendations

The Assessment Report should have a summary section that briefly discusses the data reviewed and provides a conclusion as to whether the dam is in conformance with current dam safety criteria. A list of the proposed recommendations, if any, necessary to bring the dam into conformance with applicable dam safety criteria and a schedule for completing the recommendations must be provided. The report should be reviewed with the dam owner before it is submitted to the Department.

D. Engineering Assessment Report Generation

The Engineering Assessment Report should be compiled in a 3-ring binder and should contain the results of the on-site investigations, dam safety inspections, engineering assessments, and other data or reports. All previously published dam specific hydrology, geology, hydraulic, stability, etc. reports used or referenced should be made a part of the assessment report, and may be included as an appendix. The cover page must show the Dam Name, State Dam ID#, the town/city/village and county in which the dam is located, date of the Assessment, and the name and New York PE number of the engineer who performed the Assessment, and the name and signature of the dam owner.

The Assessment Report must be stamped and signed by a professional engineer registered to practice professional engineering in New York State.

E. File Report with Department and Retain a Copy with Owner’s Records

One stamped and signed copy of the competed Engineering Assessment Report, as well as an electronic copy on CD, must be submitted to the following address:

New York State Department of Environmental Conservation
Division of Water - Dam Safety Section
625 Broadway, 4th Floor
Albany, NY 12233-3504

VI. Related References:

Dams shall be compared with safety criteria contained in:
http://www.dec.ny.gov/lands/4991.html

New York State Laws:
http://public.leginfo.state.ny.us/menugetf.cgi?COMMONQUERY=LAWS

Environmental Conservation Law 15-0507:
Structures impounding waters; structures in waters; responsibility of owner; inspection

Environmental Conservation Law 15-0503:
GUIDANCE FOR DAM ENGINEERING ASSESSMENT
Protection of water bodies; permit

Executive Law Article 2-B:
State and Local Natural and Man-Made Disaster Preparedness

New York State Regulations:
http://www.dec.ny.gov/regulations/regulations.html

Title 6 of the Official Compilation of Codes, Rules and Regulations of the State of New York (6 NYCRR):
Part 608 – Protection of Waters
Part 621 – Uniform Procedures (includes Emergency Authorization)
Part 673 – Dam Safety

Other Guidance Documents:


E.32. North Carolina
SECTION .0100 - GENERAL PROVISIONS

.0101 DEFINITIONS

.0102 DAM SAFETY ORDERS


.0103 PURPOSE

The rules and regulations contained in this Subchapter are intended to carry out the purposes of the Dam Safety Law of 1967, as expressed in G.S. 143-215.24 which authorizes the implementation of a dam inspection and certification program in the interest of public health, safety and welfare.


.0104 DEFINITIONS

As used in this Subchapter, the following terms have their stated meaning:

(1) "Applicant" means any person who has notified the department that he or she desires to construct, repair, alter, or remove a dam and requests approval by the department.

(2) "Appurtenance" means an accessory or integral subordinate structure associated with a dam, such as a spillway, conduit, walkway, valve, control gate, etc.

(3) "Articulation" means provisions for safe movement at the joint or juncture of sections of conduit.

(4) "As-built plans" means drawings, photographs, test data, and descriptions that clearly and accurately define the dam and its appurtenances after all construction is completed.

(5) "Conduit" means a natural or artificial channel or pipe through which water or other fluid is conveyed.

(6) "Critical circle" means the circle with the lowest factor of safety against mass movement in a circular arc analysis of slope stability.

(7) "Critical failure wedge" means the mass or block having the lowest factor of safety against mass movement in an analysis of slope stability along planar surfaces.

(8) "Director" means the Director of the Division of Land Resources, North Carolina Department of Natural Resources and Community Development.

(9) "Equipotential lines" means lines which represent points of equal energy level or head in a flow net.

(10) "Factor of safety" means the ratio of the forces or moments resisting mass movement to the forces or moments tending to produce mass movement.

(11) "Flow lines" means lines which represent the direction of flow in a flow net.

(12) "Flow net" means a graphical representation of flow lines and equipotential lines.

(13) "Hazard potential" means the probable damage that would occur if the
structure failed, in terms of loss of human life and economic loss or environmental damage.

(14) "Maintenance plan" means written instructions prepared by the engineer that prescribe the proper servicing and repair of mechanical equipment, appurtenances, spillways, vegetative cover, and other aspects related to the safety of the dam.

(15) "Owner" means the individual or association of individuals owning the property on which the dam exists or is to be constructed, and the persons financially responsible for the construction.

(16) "Phreatic surface" means the free-water surface of a zone of seepage; it is represented by the uppermost flow line, or seepage line, in a flow net.

(17) "Qualified engineer" means a professional engineer legally qualified to practice in North Carolina pursuant to Chapter 89C of the General Statutes of North Carolina, and having appropriate specialty expertise for the particular dam engineering problem with which he is involved.

(18) "Qualified geologist" means an earth scientist experienced in applied geology with respect to the interaction of lithologies, soils, and geologic structures with dams and impoundments, who can provide professional credentials such as certification by the American Institute of Professional Geologists or registration as a geologist in the United States.

(19) "Quality control" means that combination of testing, observation, and monitoring provided during construction to confirm that requirements stated or depicted in the plans and specifications are being achieved.

(20) "Rapid drawdown" means removal of liquid from a reservoir at a rate that is significantly faster than the rate of drainage of the materials composing the portions of the reservoir exposed by the fluid removal.

(21) "Seepage" means the movement of water in a porous material and the water exiting at the visible surface of the material.

(22) "Sliding base analysis" means an analysis of the safety of a structure against lateral movement along its foundation.

(23) "Waste treatment and mine refuse dam" means a structure for impounding, restraining, storing, or disposing of liquids, slurries, or materials capable of liquification, produced from industrial, commercial, municipal, agricultural, or mining activities.

(24) "Construction" means any action, other than by natural causes, that creates a structure capable of impounding water or other liquids, or which increases the impoundment capacity of an existing structure. For the purposes of 15A NCAC 2K .0222, it shall also mean the reduction of the height or impoundment capacity of a dam when the effect of such reduction will be to exempt the dam from the North Carolina Dam Safety Law of 1967.


.0105 CLASSIFICATION OF DAMS
(a) For the purposes of this Subchapter, dams shall be divided into three classes, which shall be known as class A (low hazard), class B (intermediate hazard), and class C (high hazard):

(1) Class A includes dams located where failure may damage uninhabited low value non-residential buildings, agricultural land, or low volume roads.

(2) Class B includes 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.

(3) Class C includes 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.
(b) Classifications shall be proposed by the design engineer and are subject to approval by the Director.
(c) Probable future development of the area downstream from the dam that would be affected by its failure shall be considered in determining the classification.
(d) Dams will be subject to reclassification if the Director determines that the hazard potential has changed. Non-structural provisions of adequately demonstrated effectiveness and reliability such as flood plain zoning, and early warning systems may be considered by the Director in making this determination.
(e) When dams are spaced so that the failure of an upper dam would likely fail a lower dam, the consequence of the lower dam's failure shall be a determining factor for the upper dam's hazard classification.
(f) In assigning a hazard classification where a bridge or roadway is the only damageable property below a dam, consideration shall be given to the possibility of loss of human life, indirect economic impact through loss of service, and direct cost of damage to the bridge or roadway.


SECTION .0200 - OBTAINING APPROVAL FOR DAM CONSTRUCTION: REPAIR OR REMOVAL

.0201 APPLICATIONS
(a) Any person(s) who proposes to construct, repair, alter or remove a dam must file with the Director a statement concerning the location of the dam, including the name of the stream and county, height, purpose, and impoundment capacity, 10 days before start of construction. If the Director determines that the proposed dam is exempt from the law, the applicant will be notified and he may then proceed with the construction.
(b) If the Director determines that the proposed dam is not exempt from the Dam Safety Law of 1967, the applicant will be so notified within 10 days of receipt of the statement described in (a) of this Rule and construction may not commence until a full and complete application has been filed and approved. This application must be filed at least 60 days before the proposed start of construction:
   (1) When an application to construct a dam has been completed pursuant to Subsection (a) of this Rule, the department shall refer copies of the completed application papers to the Department of Human Resources, the Wildlife Resources Commission, the Department of Transportation, and such other state and local agencies as it deems appropriate for review and comment.
   (2) Before commencing the repair, alteration, or removal of a dam, application shall be made for written approval by the department, except as otherwise provided by this Subchapter or in accordance with G.S. 143-215.27(b). The application shall state the name and address of the applicant; shall adequately detail the changes it proposes to effect; and shall be accompanied by maps, plans, and specifications setting forth such details and dimensions as the department requires. The department may waive such requirements in accordance with G.S. 143-215.27(a). The application shall give such other information concerning the dam and reservoir required by the department concerning the safety of any change as it may require, and shall state the proposed time of commencement and completion of the work. When an application has been completed, it may be referred by the department for agency review and report as provided by G.S. 143-215.26(b) in the case of original construction.
(c) The application for any dam shall include a preliminary report. (Filing of the preliminary report prior to filing the final design report, early in the site investigation and design schedule, is encouraged to assure the state's concurrence with the hazard classification, site investigation, and design concept. This is especially encouraged for class C dams.) The preliminary report shall be filed with the application and shall include the following information:
   (1) a general description of the dam and appurtenances and a proposed classification as set forth in Rule .0105 of this Subchapter; The description shall include a statement of the purpose for which the dam is to be used;
   (2) a description of properties located below the dam including number of homes, buildings, roads, utilities, and other property that, as determined by the engineer, would be endangered should failure of the dam occur;
   (3) maps showing the location of the proposed structure that include the county, location of state roads, access to site, and outline of the reservoir; aerial
photographs or USGS maps may be used;
(4) preliminary drawings or sketches that include cross-sections, plans and
profiles of the dam, proposed pool levels, and types of all spillways;
(5) preliminary design criteria and basis for selection including a description of the
size, ground cover conditions, and extent of development of the watershed,
drainage area, spillway design storm, geology and geotechnical engineering,
assumptions for the foundation and embankment materials, and type of materials to
be used in the principal spillways(s).
(d) The Final Design Report. A "Certificate of Approval" to construct will not be
issued until the final design report is received and approved. The preliminary report
as described in (c) of this Rule and the final design report may be submitted as one
document. The final design report shall include:
(1) a report of the investigation of the foundation soils or bedrock and the borrow
materials, including the location of borrow areas, that are to be used to construct the
dam;
(2) criteria to indicate that the dam will be stable during construction and filling
and under all conditions of reservoir operations;
(3) computations indicating that the dam is safe against overtopping during
occurrence of the inflow design flood and wave action; Wave action need not be
considered when the design flood is based on the probable maximum precipitation
(pmp);
(4) criteria, design data or references to indicate that seepage flow through the
embankment, foundation, and abutments will be controlled so that no internal
erosion will take place and so there will be no sloughing in the area where the
seepage emerges;
(5) calculations and assumptions relative to design of the spillway(s);
(6) provision to protect the upstream slope, crest, and downstream slope of earth
embankments and abutments from erosion due to wind and rain;
(7) other design data, assumptions, and analysis data pertinent to individual dams
and site conditions;
(8) a proposed construction schedule;
(9) a proposed filling schedule for the reservoir;
(10) a maintenance and operation plan;
(11) the estimated design life of the dam and the reservoir;
(12) provision for maintaining minimum stream flow requirements.
(e) The Plans and Specifications. Five sets of plans and specifications must be
submitted. The plans shall be a detailed engineering design that consists of
drawings and specifications and that include the following as a minimum:
(1) Sheet one shall show the name of the project; name of owner; hazard
classification of the dam; designated access to the project; and location with
respect to highways, roads, streams, and any dam(s) that would affect or be
affected by the proposed structure;
(2) Maps shall be included showing the drainage area and outline of the reservoir
and the ownership of properties covered by the reservoir or flood pool;
(3) Geologic investigation, cross-section, profiles, logs of borings, location of
borrow areas, drawings of principal and emergency spillways, and other additional
sheets shall be included and drawn in sufficient detail to clearly indicate the extent
and complexity of the work to be performed; The degree of detail required shall be
determined by the applicable provisions of Rules .0204 through .0212 of this
Section;
(4) The technical provisions, as may be required, to describe the method of
construction and quality control for the project;
(5) Special provisions, as may be required, to describe technical provision
needed to ensure that the dam is installed according to the approved plans and
specifications;
(6) General provisions that specify the rights, duties, and responsibilities of the
applicant, applicant's engineer and builder and the prescribed order of work.
(f) The Director, within 60 days following receipt of a completed application, shall
notify the applicant, by mail, that the application is either approved or disapproved.
An approved application shall conform to the requirements of Rule .0202 of this
Section.

History Note: Statutory Authority G.S. 143-215.26,-27,-31;

.0202 CERTIFICATE OF APPROVAL
(a) Approval of construction, repair, alteration, or removal of a dam will be
contained in a certificate called a "Certificate of Approval" to be issued by the
Director. A Certificate of Approval is a letter from the Director constituting approval subject to written general stipulations and specific written stipulations deemed necessary by the Director on a case by case basis.

(b) No construction shall be performed until the certificate is issued. The Certificate of Approval period shall be valid for the construction schedule specified in the approved final design report. Construction must commence within one year after the certificate is issued.

(c) Notice by registered or certified mail shall be given to the Director at least 10 days before construction is commenced. When repairs are necessary to safeguard life and property, they may be started immediately; but the department shall be notified forthwith of the proposed repairs and of the work under way, and they shall be made to conform to its orders.

(d) If construction does not commence within one year after the certificate of approval is issued, the certificate shall expire and a new application shall be submitted. Upon written application and for good cause shown, the Director may extend the time for commencing construction.

(e) Certificates of Approval are revocable in the event that the terms of the certificate, including the written stipulations and those terms stated in G.S. 143-215.23, are violated or in the event that conditions develop during construction that are hazardous to life and property. If the certificate is revoked due to development of hazardous conditions, the Director will issue an order requiring the owner or owners of the dam to make at his or their expense maintenance, alterations, or removal as deemed necessary within a time limited by the order; provided, any dam covered by a certificate issued under this Rule is considered to be within the definition of dams in G.S. 143-215.25 and .0104 of this Subchapter.

(f) Certificates of Approval are revocable in the event that the approved construction schedule is deviated from without prior written approval of a substitute construction schedule submitted in writing. Such approval of a substitute construction schedule shall be in the form of an Addendum to the Certificate of Approval to be issued by the Director.


.0203 PROFESSIONAL ENGINEER REQUIREMENTS
The design, preparation of the plans and specifications, inspection of the construction of or on the dam, and certification that the dam was constructed, repaired, altered, or removed according to the plans approved by the Director and that the dam or its remains are safe shall be done by a legally qualified engineer and shall bear his professional seal unless exempted under the provisions of G.S. 89C-25.


.0204 INVESTIGATIONS
(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.

History Note: Statutory Authority G.S. 143-215.26,-27,-31;

.0205 SPILLWAY DESIGN
(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
deforation. Provisions must be made for handling leakage from the channel or
underseepage from the foundation which 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:

<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>

1The factor for determining the largest size shall govern.

Minimum Spillway Design Storms
Permissible Velocities for Vegetated Earth Spillways

<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>

Permissible Velocities for Vegetated Earth Spillways

<table>
<thead>
<tr>
<th>Vegetation</th>
<th>Erosion-resistant soils</th>
<th>Easily erodable soils</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent slope of exit channel</td>
<td>Percent slope of exit channel</td>
</tr>
<tr>
<td></td>
<td>0 to 5</td>
<td>5 through 10</td>
</tr>
<tr>
<td>Bermuda grass</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Bahia grass</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Tall fescue</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Kentucky bluegrass</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Reed canary</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Sod-forming grass mixture</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Lespedeza sericea</td>
<td>3.5</td>
<td>Do not use</td>
</tr>
<tr>
<td>Weeping lovegrass</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Crabgrass</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>

2Increase values 10 percent when the anticipated average use of the spillway is not more frequent than once in 50 years or 25 percent when the anticipated average use is not more frequent than once in 100 years.


.0206 CONDUITS
(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.


.0207 SEEPAGE CONTROL

(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.


.0208 STRUCTURAL STABILITY AND SLOPE PROTECTION

(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;
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) tailwater conditions and the impact of tailwater 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.


.0209 DESIGN LIFE OF A DAM AND RESERVOIR
(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.

History Note: Statutory Authority G.S. 143-215.27; 143-215.31;

.0210 SEDIMENT CONTROL
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 
during drainage of a reservoir shall be provided; exceptions for emergency 
drainage of a reservoir may be approved by the Director.

History Note:Statutory Authority G.S. 143-215.31, -113A-54;

.0211 WASTE TREATMENT AND MINE REFUSE DAMS
(a) Waste treatment and mine refuse dams and reservoirs shall conform to all 
requirements of this Subchapter. In addition to the requirements of Rule .0105 of 
this Subchapter, a waste treatment or mine refuse dam may be classified A, B, or C 
on the basis of potential environmental damage.
(b) Mine refuse dams that are designed to be constructed in stages shall include 
an emergency spillway system that is capable of safely passing the required storm 
frequency below the top of the dam for each stage of construction. The refuse 
facility shall not be used until each stage of construction is completed and approved 
by the Director.

History Note: Statutory Authority G.S. 143-215.31;

.0212 ADDITIONAL DESIGN REQUIREMENTS
(a) All elements of the dam and reservoir shall conform to good engineering 
practice. The safety factors, design standards, and design references that are used 
shall be included with the final design report.
(b) Monitoring or inspection devices may be required by the Director for use by 
inspectors or owners in the inspection during construction and filling and after 
completion of construction. The Director may also require that such monitoring or 
inspection devices, existing or installed by requirement, be read and documented at 
specified intervals and that copies of such be forwarded to his office.
(c) The plans, construction schedule, and construction specification shall assure 
that the downstream flow satisfies minimum quality and quantity standards as 
defined in G.S. 143-215.25(4) during the period of construction, filling, and life of 
the dam and reservoir.

History Note: Statutory Authority G.S. 143-215.26; 143-215.27; 143-215.31;

.0213 CONSTRUCTION SCHEDULE
The applicant shall submit a construction schedule that includes:
(1) Techniques and work force to be used to insure that the dam is constructed 
according to the plans and specifications;
(2) A construction schedule that includes the estimated time to complete the 
construction activities;
(3) Techniques to be used to divert the stream flow to prevent interference with 
construction and hazard to life, health, or property;
(4) The extent and method of quality control shall be subject to approval of the 
Director.

History Note: Statutory Authority G.S. 143-215.26; 143-215.27; 143-215.31;
.0214 PROPOSED CHANGES IN DESIGN
The owner shall notify the director of any proposed changes in design, plans, and specifications that will affect the stability of the dam. Approval must be obtained from the Director prior to installation. This approval shall be in the form of a written addendum to the Certificate of Approval.


.0215 AS-BUILT PLANS
Two complete sets of as-built plans shall be submitted to the Director within 30 days of completion of the project.


.0216 ENGINEER'S CERTIFICATION
The engineer who has inspected the construction of or on the dam shall submit written certification bearing his professional seal, unless exempted under the provisions of G.S. 89C-25, that the dam and all appurtenances have been built, repaired, altered, or removed in conformance with the plans, specifications, and drawings approved by the Director and that the dam is safe.


.0217 AUTHORITY FOR INSPECTION
Authorized personnel of the department may make inspection during construction as deemed necessary to ensure that the structure is being built in conformance with the Certificate of Approval issued. Said inspections do not relieve the engineer in charge from the responsibility of providing adequate inspection of the work.


.0218 EXEMPTIONS


.0219 ACCEPTABLE DESIGN: PROCEDURES AND TECHNICAL REFERENCES
The following represent acceptable design procedures and references:
(1) the design procedures, manuals, and criteria used by the United States Corps of Engineers;
(2) the procedures, manuals, and criteria used by the United States Soil Conservation Service;
(3) the procedures, manuals, and criteria used by the United States Department of Interior, Bureau of Reclamation;
(4) other procedures that are approved by the Director.


.0220 GRANTING OF FINAL APPROVAL
(a) Unless the Director has reason to believe that the dam, as completed, is unsafe or not in compliance with any applicable requirement, regulation, or law, the Director, upon completion of construction and upon receipt of the engineer's certification pursuant to Rule .0215 of this Section, shall grant final approval of the work in accordance with the certificate, subject to such terms as he/she deems necessary for the protection of life and property.
(b) Pending issuance of final approval, a new dam or the addition to an existing dam shall not be used except on written consent of the Director and subject to conditions he/she may impose relating to safety of life and property and the
satisfaction of minimum stream flow requirements.


.0221 DELEGATION OF AUTHORITY
The Director has the authority to:
(1) issue approval, disapproval, or approval subject to conditions for proposed construction, repair, alteration or removal of dams;
(2) require progress reports, issue notices of non-compliance and orders to comply, order a halt in construction in the event of non-compliance;
(3) receive notices of completion, specify details of description, grant final approval;
(4) assess civil penalties; and
(5) perform other related functions.

History Note: Statutory Authority G.S. 143-215.3; 143-215.3(a)(4); 143-215.28; 143-215.29; 143-215.30; 143-215.36(b); Eff. June 15, 1980; Amended Eff. November 1, 1982.

.0222 APPLICATION PROCESSING FEES
(a) A nonrefundable minimum application processing fee, in the amount stated in Paragraph (d)(1) of this Rule, shall be paid when an application for construction or removal of a dam is filed in accordance with 15A NCAC 2K .0201. Each application for construction or removal of a dam shall be deemed incomplete and shall not be reviewed until the minimum application processing fee is paid.

(b) A nonrefundable additional application processing fee, in the amount stated in Paragraph (d)(2) of this Rule, shall be paid when the as-built plans are submitted to the Director in accordance with 15A NCAC 2K .0215. Final approval to impound, pursuant to 15A NCAC 2K .0220, shall not be granted until the owner's certification and the accompanying documentation are filed in accordance with Paragraph (e) of this Rule, and the additional processing fee is paid.

(c) The application processing fee for the construction or removal of a dam shall be based on the actual cost of construction or removal of the applicable dam.
(1) The actual cost of construction or removal of a dam shall include all labor and materials costs associated with the construction or removal of the dam and appurtenances.
(2) The actual cost of construction or removal of a dam shall not include the costs associated with acquisition of land or right of way, design, quality control, electrical generating machinery, or constructing a roadway across the dam.

(d) Schedule of Fees:
(1) The minimum application processing fee shall be two hundred dollars ($200.00).
(2) The additional application processing fee shall be the following percentages of the cost of construction or removal:
   (A) 2 percent of the actual costs between ten thousand and one dollars ($10,001) and one hundred thousand dollars ($100,000);
   (B) 1.5 percent of the actual costs between one hundred thousand and one dollars ($100,001) and five hundred thousand dollars ($500,000);
   (C) 1.0 percent of the actual costs between five hundred thousand and one dollars ($500,001) and one million dollars ($1,000,000);
   (D) 0.5 percent of the actual costs over one million dollars ($1,000,000).
In no case, however, shall the additional application fee be more than fifty thousand dollars ($50,000).

(e) Immediately upon completion of construction or removal of a dam, the owner shall file with the Director a certification, on a form prescribed by the Department, and accompanying documentation, which shows the actual cost incurred by the owner for construction or removal of the applicable dam.
(1) The owner's certification and accompanying documentation shall be filed with the as-built plans and the engineer's certification in accordance with 15A NCAC 2K .0215 and 15A NCAC 2K .0216, respectively.
(2) If the Director finds that the owner's certification and accompanying documentation contain inaccurate cost information, the Director shall either withhold final impoundment approval, or revoke final impoundment approval, until the owner provides the accurate documentation and that documentation has been verified by the Department.

(f) Payment of the dam application processing fee shall be by check or money
order made payable to the "N.C. Department of Environment, Health, and Natural Resources". The payment should refer to the applicable dam.

(g) In order to comply with the limit on fees set forth in G.S. 143-215.28A, the Director shall, in the first half of each state fiscal year, project revenues for the fiscal year from fees collected pursuant to this Rule. If this projection shows that the statutory limit will be exceeded, the Director shall order a pro rata reduction in the fee schedule for the remainder of the fiscal year to avoid revenue collection in excess of the statutory limits.

History Note: Filed as a Temporary Rule Eff. November 1, 1990 For a Period of 180 Days to Expire on
April 29, 1991;
Statutory Authority G.S. 143-215.28A;
ARRC Objection Lodged November 14, 1990;
ARRC Objection Removed December 20, 1990;

.0223 DAM HEIGHT AND STORAGE DETERMINATION

(a) For the purpose of determining size classification, the height of a dam shall be measured from the highest point on the crest of the dam to the lowest point on the downstream toe.

(b) The total storage capacity of a dam shall be that volume which would be impounded at the elevation of the highest point on the crest of the dam.

History Note: Filed as a Temporary Rule Eff. November 1, 1990 For a Period of 180 Days to Expire on
April 29, 1990;
Statutory Authority G.S. 143-215.31;
ARRC Objection Lodged November 14, 1990;
ARRC Objection Removed December 20, 1990;

SECTION .0300 - INSPECTIONS: DAM SAFETY ORDERS

.0301 INSPECTION BY THE DEPARTMENT

(a) Schedule of Inspections
(1) All class A and B dams shall be inspected at least once every five years.
(2) Class C dams shall be inspected at least once every two years.

(b) At any time an inspection indicates that a dam may not perform satisfactorily or that the hazard classification has changed, the Director may require a detailed investigation at the owners expense to determine the required remedial action, if any.

History Note: Statutory Authority G.S. 143-215.31; 143-215.32;

.0302 DAM SAFETY ORDERS

(a) The Director may issue an order directing the owner(s) of a dam to make, in not less than 90 days from issuance of the order and at the owner(s) expense, any maintenance, alteration, repairs, reconstruction, or change in construction upon a finding that the dam:
(1) is not sufficiently strong,
(2) is not maintained in good repair or operating condition,
(3) is dangerous to life or property, or
(4) does not satisfy minimum stream-flow requirements.

(b) The Director may issue an order directing the owner(s) of any dam to take such measures as may be essential, including lowering the level of the impounded water, drainage of the impoundment, and destruction of the dam or reservoir in whole or in part, immediately or within a time limited by the order if the condition of the dam is found to have become so dangerous to the safety of life or property, in the opinion of the Director, as not to safely permit sufficient time for issuance of an order in the manner provided by Subdivision (a) of this Rule.

(c) The Director may, if at any time the condition of any dam becomes so dangerous to the safety of life or property, in the opinion of the Director, as not to permit sufficient time for issuance of an order in the manner provided by Subdivision (a) or (b) of this Rule, immediately take such measures as may be essential to provide
emergency protection to life and property including the lowering of the level of a reservoir by releasing water impounded or the destruction in whole or in part of the dam or reservoir. Costs of such measures may be recovered from the owner(s) of the dam by appropriate legal action by the Commission.

(d) Orders issued by the Director may be conditioned so as to require the dam owner, if he is required or given the option to remove the dam, to undertake the removal in such a manner as to minimize the amount of sediment transported from the impoundment downstream.

(e) Dam safety orders issued by the Director in no way relieve the owner(s) of the dam from duties and obligations imposed by regulations in Section .0200 of this Subchapter, nor do they relieve the owner(s) of the dam from any liabilities or other legal obligations.


SECTION .0400 - ADMINISTRATIVE HEARINGS

.0401 OPPORTUNITY FOR HEARING

An administrative hearing before the N.C. Office of Administrative Hearings shall be granted to any person:

(1) whose application for dam construction, repair, alteration, or removal has been disapproved by the Director or has been approved by the Director subject to conditions which are unacceptable to the applicant pursuant to Rule .0202 of this Subchapter;

(2) who has been denied final approval of a completed dam by the Director or who has been granted final approval by the Director subject to conditions which are unacceptable to the applicant pursuant to Rule .0219 of this Subchapter;

(3) against whom a dam safety order has been issued requiring the maintenance, alteration, repair, reconstruction, change in construction or location, or removal of a dam within 90 days, pursuant to Rule .0302(a) of this Subchapter, or the lowering of the level of the water impounded by the dam within a time period prescribed by the Director pursuant to Rule .0302(b) of this Subchapter, or

(4) who has been assessed a civil penalty pursuant to G.S. 143-215.36(b) and Subchapter 2J of this Chapter.


.0402 PROCEDURES

(a) Administrative hearings shall be conducted pursuant to 15A NCAC 1B .0200 et seq., and Chapter 150B of the General Statutes. Any person entitled to an opportunity for a hearing by Rule .0401 of this Section must request a hearing within ten days after receipt of the notice of the action taken under Rule .0401 of this Section.

(b) Copies of 15A NCAC 1B .0200 may be inspected in the offices of the Division of Land Resources, Land Quality Section, 512 N. Salisbury Street, Raleigh, N. C. 27611. Copies may also be inspected in the Division of Planning and Assessment, 512 N. Salisbury Street, 8th Floor, Archdale Building, Raleigh, N. C. 27611. Copies may be obtained at the previous locations or from the Rules Division of the N.C. Office of Administrative Hearings, Blount Street, Raleigh, N.C. 27611.


.0403 DELEGATION OF AUTHORITY: APPOINTMENT OF HEARING OFFICERS

.0404 NOTICE: WAIVER

.0405 PLACE OF THE HEARING

.0406 PROCEDURES

.0407 HEARING OFFICERS: POWERS AND DUTIES

.0408 FINAL DECISIONS: JUDICIAL REVIEW

History Note: Statutory Authority G.S. 143-215.3(a)(4); 143-215.33; 150B-23; 150B, Article 3;
SECTION .0500 - MINIMUM STREAM FLOWS TO MAINTAIN AQUATIC HABITAT

.0501 DEFINITIONS
(a) Aquatic habitat shall be divided into three classes - "poor," "moderate," and "good."
(1) Streams with poor aquatic habitat are those which have a "poor" fish assemblage rating, and which are rated "poor" for at least two of the following three characteristics:
   (A) Substrate;
   (B) Cover; and
   (C) Macro-invertebrate organisms.
(2) Streams with moderate aquatic habitat are those which exhibit physical conditions and biota which are intermediate between the poor and good categories.
(3) Streams with good aquatic habitat are those which receive at least two "good" ratings when the substrate, cover, and macro-invertebrate organism characteristics are evaluated. The fish assemblage also must receive a "good" rating.
(b) Cover means objects within or overhanging the stream channel which provide shelter for aquatic organisms. "Good" cover occurs when cover is widespread and diverse. "Poor" cover occurs when the amount of cover is small or non-existent.
(c) Substrate means the predominant particle size of the material which makes up the stream bed. "Good" substrate is composed of at least 50 percent silt free substrate with gravel or cobble. "Poor" substrate is composed of at least 80 percent silt, sand, or smooth bedrock.
(d) The macro-invertebrate organisms of the affected reach are rated as "good" if the affected reach is rated good or excellent in the Division of Environmental Management's (DEM) biological monitoring database, or by a site-specific survey according to Standard Operating Procedures for Biological Monitoring, 1995, Division of Environmental Management as defined in 15A NCAC 2B .0103(b). Macro-invertebrates are rated "poor" if the reach is rated fair or poor in DEM’s biological monitoring database, or by a site-specific survey according to Standard Operating Procedures for Biological Monitoring, 1995, Division of Environmental Management as defined in 15A NCAC 2B .0103(b).
(e) The fish assemblage rating shall be based on the North Carolina Index of Biotic Integrity (IBI). Existing ratings from the DEM biological monitoring database shall be used where available. If no rating exists, then a site-specific survey shall be conducted according to Standard Operating Procedures for Biological Monitoring, 1995, Division of Environmental Management as defined in 15A NCAC 2B .0103(b). The fish assemblage shall be rated as "good" if the IBI rating is good, good-excellent, or excellent. The fish assemblage shall be rated as "poor" if the IBI rating is poor or lower.
(f) The affected reach of stream means that section of a stream downstream of a dam which experiences significant changes in hydrology. The exact delineation of the affected reach shall be site-specific and depend on factors including, but not limited to:
   (1) volume of storage in the impoundment;
   (2) upstream and downstream hydrologic characteristics of the stream;
   (3) withdrawals from the impoundment; and
   (4) downstream point source discharges to the stream.
For the purpose of evaluating aquatic habitat, the affected reach of a stream does not include any portion which is in the backwater of a downstream dam when the level of that downstream impoundment is at normal pool.
(g) "Special case" streams are those which exhibit at least one of the following characteristics:
   (1) supplemental classification as an Outstanding Resource Water as defined in 15A NCAC 2B .0101(e)(4) and .0216;
   (2) populations of aquatic species listed as threatened or endangered by the U.S. Fish and Wildlife Service, or species which are listed as threatened or endangered by the N.C. Wildlife Resources Commission;
   (3) self-sustaining populations of wild trout; or
   (4) exceptional non-game or fishery resources as determined by the Wildlife Resources Commission.
The use of the regression equations in Rule .0502 of this Section shall depend on the geographic region of the state in which the stream is located. The geographic region shall be determined from the North Carolina Atlas, edited by Clay, Orr, and Stuart, published by the University of North Carolina Press, 1975.

A continuous stream gage record means a continuous record of daily flows from a stream gage which:
(1) has at least 15 years of continuous daily records;
(2) has no significant hydrological effects caused by upstream regulation, withdrawals, or discharges;
(3) is no less than one-half and no more than one and one-half times the drainage area of the site in question; and
(4) has low flow and average flow yields which are comparable to the site in question.

A site-specific instream flow study conducted by the applicant or his consultants, which is subject to approval by the Department, means a study performed according to the following conditions:
(1) A plan of study shall be developed in consultation with the Department and submitted to the Department for review and approval prior to commencement of the study.
(2) The plan of study shall identify the aquatic habitat parameters to be evaluated by the study. The selection of these parameters shall depend on factors including, but not limited to:
(A) the aquatic species being evaluated;
(B) the habitat quality of the affected reach; and
(C) existing or potential water shortages or water use conflicts.
(3) The Department shall have the option of participating in the collection of all field data, and shall be notified prior to collection of any set of data.
(4) The results of the study shall accurately determine the parameters identified during study design.
(5) The Department may review the field data and results of these studies to determine the stream flow needed to maintain aquatic habitat.


.0502 REQUIRED MINIMUM FLOW FOR DAMS (NOT SMALL HYDRO PROJECTS)
(a) A dam operated by a small power producer, as defined in G.S. 62-3(27a), that diverts water from 4,000 feet or less of the natural stream bed, shall be exempt from this Rule.
(b) A dam proposed for a small stream with a mean annual daily flow less than or equal to 3.0 cubic feet per second (cfs) shall be subject to the following review process in determining the required minimum flow:
(1) If the mean annual daily flow is less than or equal to 3.0 cfs and the 7-day, 10-year low flow (7Q10) is less than or equal to 0.2 cfs; and if there are no existing point source discharges of wastewater to the affected stream reach; then no minimum release will be required.
(2) If the mean annual daily flow is less than or equal to 3.0 cfs and the 7Q10 is less than or equal to 0.2 cfs; and one or more existing point source discharges of wastewater enter the affected stream reach; then the minimum release shall be equal to the 7Q10.
(3) If the mean annual daily flow is greater than 3.0 cfs, then the following procedures shall be used to determine the minimum flow requirement:
(a) The minimum flow for a dam on a stream with poor aquatic habitat shall be the 7Q10 flow determined by using U.S. Geological Survey procedures.
(b) The minimum flow for a dam on a stream with moderate aquatic habitat in the piedmont, as defined in Rule .0501(h) of this Section, shall be determined using regression equations provided in this Subparagraph.
(A) All flows used in regression equations shall be measured in cubic feet per second, all drainage areas shall be measured in square miles, and all logarithmic expressions shall refer to base 10 logarithms.
(B) The regression equation used to determine the minimum flow for a stream in the piedmont which exhibits moderate aquatic habitat, and for which no continuous
stream gage record, as defined in Rule .0501(i) of this Section, exists, shall be as follows:

\[ \text{LRF} = (3.204 \times M) - (2.618 \times D) \]

LRF = LOG of regression flow
M = LOG of mean annual daily flow
D = LOG of drainage area

The regression flow (RF) is calculated by raising 10 to the power of the LRF. If the drainage area is greater than 95 square miles, the required minimum flow is 1.4 x RF. Otherwise the required minimum flow is equal to RF.

(C) The regression equation used to determine the minimum flow for a stream in the piedmont which exhibits moderate aquatic habitat, and for which a continuous stream gage record, as defined in Rule .0501(i) of this Section, does exist, shall be as follows:

\[ \text{LRF} = (0.812 \times M) + (8.111 \times E92) - (4.806 \times E85) - (3.275 \times E95) \]

LRF = LOG of regression flow
M = LOG of mean annual daily flow
E85 = LOG of 85% annual exceedance flow
E92 = LOG of 92.5% annual exceedance flow
E95 = LOG of 95% annual exceedance flow

The regression flow (RF) is calculated by raising 10 to the power of the LRF. The required minimum flow is 1.1 x RF.

(3) The minimum flow for a dam on a stream with moderate aquatic habitat, located in a geographical region for which regression formulas are not provided, shall be determined by a site-specific instream flow study, as defined in Rule .0501(j) of this Section, conducted by the applicant or his consultants and subject to the approval of the Department.

(4) The minimum flow for a dam on a special case stream, or on a stream with good aquatic habitat, shall be determined by a site-specific instream flow study, as defined in Rule .0501(j). This study shall be conducted by the applicant or his consultants, and shall be subject to approval by the Department.

(5) If the applicant or owner disputes the minimum flow determined by the procedures described in Subparagraphs (c)(1) or (c)(2) of this Rule for streams with poor or moderate aquatic habitat, he may undertake a site-specific field study, as defined in Rule .0501(j) of this Section, subject to the review and approval of the Department. The final minimum release required will not exceed the amount determined by the procedures described in this Rule.

(6) The minimum release schedule for a water supply reservoir shall include provisions for reductions in the minimum flow which coincide with reductions in the usable water supply storage remaining in the impoundment and with reductions in the amount of water withdrawn from the reservoir.

(A) This system of tiered releases shall apply to new water supply reservoirs and any existing water supply reservoirs for which the minimum release is revised.

(B) The exact percentage of storage which triggers reductions in minimum flow will depend on several site-specific factors, including, but not limited to:

(i) size of the reservoir;
(ii) rate of the water supply demand;
(iii) hydrologic characteristics of the impounded stream; and
(iv) the impoundment levels which result in local efforts to reduce water usage through conservation measures.

(C) At least three levels of minimum releases shall be included in the release schedule for a water supply reservoir.

(D) When usable water supply storage has been reduced to a level which triggers the first reduction in minimum flow, then the average daily water withdrawal shall be reduced by at least 10 percent from the average daily withdrawal for the 60 day period immediately prior to the first reduction in the minimum flow. The water supply operator shall accomplish this reduction in withdrawal within two weeks of the reduction in the minimum release.

(E) When usable water supply storage has been reduced to a level which triggers the second reduction in minimum flow, then the average daily water withdrawal shall be reduced by at least 20 percent from the average daily withdrawal for the 60 day period immediately prior to the first reduction in the minimum flow. The water supply operator shall accomplish this further reduction in withdrawal within two weeks of the reduction in the minimum release.

http://www.dlr.enr.state.nc.us/pages/dam15asub.html

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weeks of the second reduction in the minimum release.

(F) The water system operator shall document reduction in water withdrawals by submitting reports of daily water withdrawals to the Department. These shall be submitted every two weeks for as long as the minimum release is reduced below the amount normally required.

(G) An example is shown in the table below. (Note that the percentages of water supply storage which trigger the changes in minimum release are site-specific for this example and may vary according to the factors described in Part (B) of this Paragraph.)

<table>
<thead>
<tr>
<th>Remaining Usable Water Level Supply Storage</th>
<th>Minimum Release</th>
<th>Water Use Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>between 70% and 100%</td>
<td>A</td>
<td>--------</td>
</tr>
<tr>
<td>between 40% and 70%</td>
<td>B</td>
<td>10%</td>
</tr>
<tr>
<td>below 40%</td>
<td>C</td>
<td>20%</td>
</tr>
</tbody>
</table>

A = Normal minimum release determined by a field study, regression equation, or use of the 7Q10
B = Intermediate reduction in minimum release
C = Low minimum release equal to no more than the 7Q10

(7) An existing dam which was built subject to review under the National or the State Environmental Policy Acts, and for which a minimum release has been established, will not have its minimum release changed under this Rule. However, the Department may review and adjust the minimum flow released by any other existing dam if there is evidence of any of the following conditions downstream of that dam:

(A) water quality standards not being maintained;
(B) water quality classifications which are being only partially supported or not being supported; or
(C) aquatic habitat not being maintained.

(8) If the minimum release required from an existing water supply reservoir is reviewed by the Department, any increase in minimum flow will be determined on a case-by-case basis in consideration of the following factors, including, but not limited to:

(A) availability of water to meet existing demands;
(B) rate of growth in water demand;
(C) planned development of alternative sources of water supply;
(D) structural difficulties;
(E) capital costs; and
(F) anticipated improvements in water quality and aquatic habitat in the affected reach resulting from the proposed change in minimum flow.

The change in minimum release shall be set no higher than an amount which would reduce the water supply safe yield, as determined by standard accepted engineering practices, by more than 10 percent.

(9) If a new minimum release requirement from an existing water supply reservoir is being delayed until a new source of water supply is developed, then this delay shall not exceed a period of five years from the written notification that a new minimum release will be required. This period may be extended by approval of the Environmental Management Commission in consideration of the following factors:

(A) delays in developing a new water supply source;
(B) changes in water quality and aquatic habitat in the affected reach; or
(C) availability of water to meet existing demands.


.0503 REQUIRED MINIMUM FLOW FOR SMALL HYDROELECTRIC PROJECTS

(a) This Rule shall apply only to a dam operated by a small power producer, as defined in G.S. 62-3(27a), that diverts water from 4,000 feet or less of the natural stream bed. The length of the bypassed reach shall be measured from the toe of the dam to the point where the diverted water re-enters the natural channel,
following the centerline of the natural channel.

(b) The minimum release for a hydroelectric project subject to this Rule shall be determined according to the procedures described in Subparagraphs (1)-(5) of this Paragraph. If at any time the inflow just upstream of the dam is less than the minimum flow required in the bypassed reach, then the minimum flow may be reduced to a level equal to this inflow.

(1) If the aquatic habitat in the bypassed reach is rated poor, then the minimum release to the bypassed reach shall be determined as follows:
   (A) If the 7Q10 is less than or equal to 10 percent of the mean annual daily flow, then the minimum release to the bypassed reach shall be the 7Q10 flow.
   (B) If the 7Q10 is greater than 10 percent of the mean annual daily flow, and there are no existing point source discharges of wastewater to the bypassed reach, then the minimum release to the bypassed reach shall be 0.8 times the 7Q10.
   (C) If the 7Q10 is greater than 10 percent of the mean annual daily flow, and one or more existing point source discharges of wastewater enter the bypassed reach, then the minimum release to the bypassed reach shall be the 7Q10 flow.

(2) If the bypassed reach does not have an aquatic habitat rating of "poor," is not on a special case stream, and is located in the piedmont region, as defined in Rule .0501(h) of this Section, then the minimum release to the bypassed reach shall be determined as follows:
   (A) If the 7Q10 is less than or equal to six percent of the mean annual daily flow, then the minimum release to the bypassed reach shall be 3.0 times the 7Q10 flow.
   (B) If the 7Q10 is greater than six percent of the mean annual daily flow, and less than or equal to 10 percent of the mean annual daily flow, then the minimum release to the bypassed reach shall be 2.2 times the 7Q10 flow.
   (C) If the 7Q10 is greater than 10 percent of the mean annual daily flow, then the minimum release to the bypassed reach shall be 1.2 times the 7Q10 flow.

(3) The minimum flow determined by the procedures described in Subparagraphs (1) and (2) of this Paragraph may be adjusted downward by the Department if that adjustment would not result in significant loss of aquatic habitat. This adjustment may be based on factors including:
   (A) the type of aquatic habitat present in the bypassed reach;
   (B) the length of the bypassed reach.

(4) If the applicant or owner disputes the minimum flow determined by the procedures described in Subparagraphs (1) and (2) of this Paragraph, he may undertake a site-specific field study, as defined in Rule .0501(j) of this Section, subject to the review and approval of the Department. The final minimum release required will not exceed the amount determined by the procedures described in this Section.

(5) The minimum flow for a dam on a special case stream, or on a stream located in the mountain region, as defined in Rule .0501(h) of this Section, which does not exhibit poor aquatic habitat; shall be determined by a site-specific instream flow study, as defined in Rule .0501(j) of this Section. This study shall be conducted by the applicant or his consultants, and shall be subject to approval by the Department.

(c) A dam operated by a small power producer, as defined in G.S. 62-3(27a), which was operating to produce power as of October 13, 1994, and which is not under the jurisdiction of the Federal Energy Regulatory Commission, shall not be required by this Rule to increase its minimum flow above the amount required on October 13, 1994.


.0504 MONITORING OF MINIMUM FLOW REQUIREMENTS

(a) An owner of a dam with a minimum flow requirement greater than 1.0 cfs shall install, calibrate, and maintain one or more stream staff gages following procedures described in U.S. Geological Survey Water Supply Paper 2175, "Measurement and Computation of Streamflow." Plans for such gages shall be submitted to the Department for approval prior to installation. Staff gages shall be calibrated to indicate the water surface elevations which correspond to the required flows. Calibration shall be verified at least every two years. All initial calibration and re-calibration measurements, including field data, shall be provided to the Department within 30 days of completion.

(b) If the minimum release from a dam is less than or equal to 1.0 cfs, then an
accurately calibrated release mechanism such as a gate or pipe opening shall be acceptable in lieu of a staff gage. Plans for making the required release shall be submitted to the Department for review and approval prior to construction, repair, or modification of the dam.

(c) An owner of a dam who does not comply with a minimum flow requirement may be required to install automated gaging which continuously monitors flow. Records from this type of gage shall be provided to the Department upon request, for the time period being investigated.

(d) Minimum release requirements may be modified or suspended for a term determined by the Department for reasons including pre-scheduled maintenance or construction involving the dam. The Department must approve a written request for such a change in the minimum flow requirement prior to any change in the minimum release.

(e) Reduction or cessation of the minimum flow as a result of emergency conditions or equipment failure shall not constitute a violation of the minimum flow requirement, so long as the event is reported to the Department within 48 hours. The Department may set forth a schedule for correcting the problem and restoring the required minimum flow. If the schedule is not met, and the problem continues to cause violation of the minimum flow requirement, then this violation may be subject to enforcement action.

History Note: Statutory Authority G.S. 143-215.24; 143-215.25; 143-215.31; 143-215.32; 143-215.33;
143-215.36; 143-215.36;
### Dam Hazards Classification

<table>
<thead>
<tr>
<th>Hazard Classification</th>
<th>Description</th>
<th>Quantitative Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Interruption of road service, low volume roads</td>
<td>Less than 25 vehicles per day</td>
</tr>
<tr>
<td></td>
<td>Economic damage</td>
<td>Less than $30,000</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Damage to highways, Interruption of service</td>
<td>25 to less than 250 vehicles per day</td>
</tr>
<tr>
<td></td>
<td>Economic damage</td>
<td>$30,000 to less than $200,000</td>
</tr>
<tr>
<td>High</td>
<td>Loss of human life*</td>
<td>Probable loss of 1 or more human lives</td>
</tr>
<tr>
<td></td>
<td>Economic damage</td>
<td>More than $200,000</td>
</tr>
<tr>
<td></td>
<td>*Probable loss of human life due to breached</td>
<td>250 or more vehicles per day</td>
</tr>
<tr>
<td></td>
<td>roadway or bridge on or below the dam.</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** Cost of dam repair and loss of services should be included in economic loss estimate if the dam is a publicly owned utility, such as a municipal water supply dam.

This Part shall be known and may be cited as the Dam Safety Law of 1967. (1967, c. 1068, s. 1.)


It is the purpose of this Part to provide for the certification and inspection of dams in the interest of public health, safety, and welfare, in order to reduce the risk of failure of dams; to prevent injuries to persons, damage to downstream property and loss of reservoir storage; and to ensure maintenance of minimum stream flows of adequate quantity and quality below dams. (1967, c. 1068, s. 2; 1977, c. 878, s. 1; 1993, c. 394, s. 1.)


As used in this Part, unless the context otherwise requires:

(1) "Dam" means a structure and appurtenant works erected to impound or divert water.

(2) "Minimum stream flow" or "minimum flow" means a stream flow of a quantity and quality sufficient in the judgment of the Department to meet and maintain stream classifications and water quality standards established by the Department under G.S. 143-214.1 and applicable to the waters affected by the project under consideration, and to maintain aquatic habitat in the length of the stream that is affected. (1967, c. 1068, s. 3; 1973, c. 1262, ss. 23, 38; 1977, c. 771, s. 4; c. 878, ss. 2, 4; 1983, c. 306; 1987, c. 827, ss. 154, 175; 1993, c. 394, s. 2.)

§ 143-215.25A. Exempt dams.

(a) Except as otherwise provided in this Part, this Part does not apply to any dam:

(1) Constructed by the United States Army Corps of Engineers, the Tennessee Valley Authority, or another agency of the United States government, when the agency designed or approved plans for the dam and supervised its construction.

(2) Constructed with financial assistance from the United States Soil Conservation Service, when that agency designed or approved plans for the dam and supervised its construction.

(3) Licensed by the Federal Energy Regulatory Commission, or for which a license application is pending with the Federal Energy Regulatory Commission.

(4) For use in connection with electric generating facilities under the jurisdiction of the North Carolina Utilities Commission.

(5) Under a single private ownership that provides protection only to land or other property under the same ownership and that does not pose a threat to human life or property below the dam.

(6) That is less than 15 feet in height or that has an impoundment capacity of less than 10 acre-feet, unless the Department determines that failure of the dam could result in loss of human life or significant damage to property below the dam.

(b) The exemption from this Part for a dam described in subdivisions (1) and (2) of subsection (a) of this section does not apply after the supervising federal agency relinquishes authority for the operation and maintenance of

(a) No person shall begin the construction of any dam until at least 10 days after filing with the Department a statement concerning its height, impoundment capacity, purpose, location and other information required by the Department. A person who constructs a dam, including a dam that is otherwise exempt from this Part under subdivisions (4) or (5) of G.S. 143-215.25A(a), shall comply with the malaria control requirements of the Department. If on the basis of this information the Department is of the opinion that the proposed dam is not exempt from the provisions of this Part, it shall so notify the applicant, and construction shall not be commenced until a full application is filed by the applicant and approved as provided by G.S. 143-215.29. The Department may also require of applicants so notified the filing of any additional information it deems necessary, including, but not limited to, streamflow and rainfall data, maps, plans and specifications. Every applicant for approval of a dam subject to the provisions of this Part shall also file with the Department the certificate of an engineer legally qualified in this State. The certificate shall state that the person who files the certificate is responsible for the design of the dam and that the design is safe and adequate.

(b) The Department shall send a copy of each completed application to the State Health Director, the Wildlife Resources Commission, the Department of Transportation, and other State and local agencies it considers appropriate for review and comment. (1967, c. 1068, s. 4; 1973, c. 476, s. 128; c. 507, s. 5; c. 1262, s. 23; 1987, c. 827, s. 176; 1989, c. 727, s. 163; 1993, c. 394, s. 4; 1995, c. 509, s. 80.)

§ 143-215.27. Repair, alteration, or removal of dam.

(a) Before commencing the repair, alteration or removal of a dam, application shall be made for written approval by the Department, except as otherwise provided by this Part. The application shall state the name and address of the applicant, shall adequately detail the changes it proposes to effect and shall be accompanied by maps, plans and specifications setting forth such details and dimensions as the Department requires. The Department may waive any such requirements. The application shall give such other information concerning the dam and reservoir required by the Department, such information concerning the safety of any change as it may require, and shall state the proposed time of commencement and completion of the work. When an application has been completed it may be referred by the Department for agency review and report, as provided by subsection (b) of G.S. 143-215.26 in the case of original construction.

(b) When repairs are necessary to safeguard life and property they may be started immediately but the Department shall be notified forthwith of the proposed repairs and of the work under way, and they shall be made to conform to its orders. (1967, c. 1068, s. 5; 1979, c. 55, s. 1.)

§ 143-215.28. Action by Commission upon applications.

(a) Following receipt of agency comments the Commission shall approve, disapprove, or approve subject to conditions necessary to ensure safety and to satisfy minimum stream flow requirements, all applications made pursuant to this Part.

(b) A defective application shall not be rejected but notice of the defects shall be sent to the applicant by registered mail. If the applicant fails to file a perfected application within 30 days the original shall be canceled unless further time is allowed.

(c) If the Commission disapproves an application, one copy shall be returned with a statement of its objections. If an application is approved, the approval shall be attached thereto, and a copy returned by registered mail. Approval shall be granted under terms, conditions and limitations which the Commission deems necessary to safeguard life and property.

(d) Construction shall be commenced within one year after the date of approval of the application or such approval is void. The Commission upon written application and good cause shown may extend the time for commencing construction. Notice by registered mail shall be given the Commission at least 10 days before construction is commenced. (1967, c. 1068, s. 6; 1973, c. 1262, s. 23; 1987, c. 827, s. 154.)

§ 143-215.28A. Application fees.

(a) In accordance with G.S. 143-215.3(a)(1a), the Commission may establish a fee schedule for processing applications for approvals of construction or removal of dams issued under this Part. In establishing the fee schedule, the Commission shall consider the administrative and personnel costs incurred by the Department for processing the applications and for related compliance activities. The total amount of fees collected in any fiscal year may not exceed one-third of the total personnel and administrative costs incurred by the Department for processing the applications and for related compliance activities in the prior fiscal year. An approval fee may not exceed the larger of two hundred dollars ($200.00) or two percent (2%) of the actual cost of construction or
removal of the applicable dam. The provisions of G.S. 143-215.3(a)(1b) do not apply to these fees.

(b) The Dam Safety Account is established as a nonreverting account within the Department. Fees collected under this section shall be credited to the Account and shall be applied to the costs of administering this Part. (1989 (Reg. Sess., 1990), c. 976, s. 1; 1991 (Reg. Sess., 1992), c. 1039, s. 15; 1993, c. 394, s. 5.)

§ 143-215.29. Supervision by qualified engineers; reports and modification during work.

(a) Any project for which the Commission's approval is required under G.S. 143-215.26, 143-215.27, and 143-215.28, and any project undertaken pursuant to an order of the Commission issued pursuant to this section or G.S. 143-215.32 shall be designed and supervised by an engineer legally qualified in the State of North Carolina.

(b) During the construction, enlargement, repair, alteration or removal of a dam, the Commission may require such progress reports from the supervising engineer as it deems necessary.

(c) If during construction, reconstruction, repair, alteration or enlargement of any dam, the Commission finds the work is not being done in accordance with the provisions of the approval and the approved plans and specifications, it shall give written notice by registered mail or personal service to the person who received the approval and to the person in charge of construction at the dam. The notice shall state the particulars in which compliance has not been made, and shall order immediate compliance with the terms of the approval, and the approved plans and specifications. The Commission may order that no further construction work be undertaken until such compliance has been effected and approved by the Commission. A failure to comply with the approval and the approved plans and specifications shall render the approval revocable unless compliance is made after notice as provided in this section. (1967, c. 1068, s. 7; 1973, c. 1262, s. 23; 1977, c. 878, s. 5; 1987, c. 827, s. 154.)

§ 143-215.30. Notice of completion; certification of final approval.

(a) Immediately upon completion, enlargement, repair, alteration or removal of a dam, notice of completion shall be given the Commission. As soon as possible thereafter supplementary drawings or descriptive matter showing or describing the dam as actually constructed shall be filed with the Department in such detail as the Commission may require.

(b) When an existing dam is enlarged, the supplementary drawings and descriptive matter need apply only to the new work.

(c) The completed work shall be inspected by the supervising engineers, and upon finding that the work has been done as required and that the dam is safe and satisfies minimum streamflow requirements, they shall file with the Department a certificate that the work has been completed in accordance with approved design, plans, specifications and other requirements. Unless the Commission has reason to believe that the dam is unsafe or is not in compliance with any applicable rule or law, the Commission shall grant final approval of the work in accordance with the certificate, subject to such terms as it deems necessary for the protection of life and property.

(d) Pending issuance of the Commission's final approval, the dam shall not be used except on written consent of the Commission, subject to conditions it may impose. (1967, c. 1068, s. 7; 1973, c. 1262, s. 23; 1977, c. 878, s. 5; 1987, c. 827, ss. 154, 177.)

§ 143-215.31. Supervision over maintenance and operation of dams.

(a) The Commission shall have jurisdiction and supervision over the maintenance and operation of dams to safeguard life and property and to satisfy minimum streamflow requirements. The Commission may adopt standards for the maintenance and operation of dams as may be necessary for the purposes of this Part. The Commission may vary the standards applicable to various dams, giving due consideration to the minimum flow requirements of the stream, the type and location of the structure, the hazards to which it may be exposed, and the peril of life and property in the event of failure of a dam to perform its function.

(b) The Department, consistent with rules adopted by the Commission, may impose any condition or requirement in orders and written approvals issued under this Part that is necessary to ensure that stream classifications, water quality standards, and aquatic habitat requirements are met and maintained, including conditions and requirements relating to the release or discharge of designated flows from dams, the location and design of water intakes and outlets, the amount and timing of the withdrawal of water from a reservoir, and the construction of submerged weirs or other devices intended to maintain minimum streamflows. The Commission shall adopt rules that specify the minimum streamflow in the length of the stream affected.

(c) The minimum streamflow in the length of the stream affected by a dam that is operated by a small power
producer, as defined in G.S. 62-3(27a), that diverts water from 4,000 feet or less of the natural streambed and where the water is returned to the same stream shall be:

(1) The minimum average flow for a period of seven consecutive days that would have an average occurrence of once in 10 years in the absence of the dam, or ten percent (10%) of the average annual flow of the stream in the absence of the dam, whichever is less, if prior to 1 January 1995 the small power producer was either licensed by the Federal Energy Regulatory Commission or held a certificate of public convenience and necessity issued by the North Carolina Utilities Commission.

(2) The minimum average flow for a period of seven consecutive days that would have an average occurrence of once in 10 years in the absence of the dam, or ten percent (10%) of the average annual flow of the stream in the absence of the dam, whichever is greater, if subdivision (1) of this subsection does not apply.

(3) To protect the habitat of the Cape Fear Shiner and other aquatic species, 28 cubic feet per second for any dam that diverts water from 2,500 feet or more of the natural streambed of any stream on which six or more dams operated by small power producers were located on 1 January 1995, notwithstanding subdivisions (1) and (2) of this subsection.

(d) Subsection (c) of this section establishes the policy of this State with respect to minimum streamflows in the length of the stream affected by a dam that is operated by a small power producer, as defined in G.S. 62-3(27a), that diverts water from 4,000 feet or less of the natural streambed and where the water is returned to the same stream, whether the dam is subject to or exempt from this Part. In its comments and recommendations to the Federal Energy Regulatory Commission regarding the minimum streamflow in the length of the stream affected by a dam that is operated by a small power producer, as defined in G.S. 62-3(27a), that diverts water from 4,000 feet or less of the natural streambed and where the water is returned to the same stream, the Commission and the Department shall not advocate or recommend a minimum streamflow that exceeds the minimum streamflow that would be required under subsection (c) of this section.

(e) The minimum streamflow in the length of the stream affected by a dam to which subsections (c) and (d) of this section do not apply shall be established as provided in subsection (b) of this section. Subsections (c) and (d) of this section do not apply if the length of the stream affected:

(1) Receives a discharge of waste from a treatment works for which a permit is required under Part 1 of this Article; or

(2) Includes any part of a river or stream segment that:

a. Is designated as a component of the State Natural and Scenic Rivers System by G.S. 113A-35.1 or G.S. 113A-35.2.

b. Is designated as a component of the national Wild and Scenic Rivers System by 16 U.S.C. § 1273 and 1274. (1967, c. 1068, s. 9; 1973, c. 1262, s. 23; 1987, c. 827, s. 154; 1993, c. 394, s. 6; c. 553, s. 80; 1995, c. 184, s. 1; c. 439, s. 1.)

§ 143-215.32. Inspection of dams.

(a) The Department may at any time inspect any dam, including a dam that is otherwise exempt from this Part, upon receipt of a written request of any affected person or agency, or upon a motion of the Environmental Management Commission. Within the limits of available funds the Department shall endeavor to provide for inspection of all dams at intervals of approximately five years.

(b) If the Department upon inspection finds that any dam is not sufficiently strong, is not maintained in good repair or operating condition, is dangerous to life or property, or does not satisfy minimum streamflow requirements, the Department shall present its findings to the Commission and the Commission may issue an order directing the owner or owners of the dam to make at his or her expense maintenance, alterations, repairs, reconstruction, change in construction or location, or removal as may be deemed necessary by the Commission within a time limited by the order, not less than 90 days from the date of issuance of each order, except in the case of extreme danger to the safety of life or property, as provided by subsection (c) of this section.

(c) If at any time the condition of any dam becomes so dangerous to the safety of life or property, in the opinion of the Environmental Management Commission, as not to permit sufficient time for issuance of an order in the manner provided by subsection (b) of this section, the Environmental Management Commission may immediately take such measures as may be essential to provide emergency protection to life and property, including the lowering of the level of a reservoir by releasing water impounded or the destruction in whole or in part of the dam or reservoir. The Environmental Management Commission may recover the costs of such measures from the owner or owners by appropriate legal action.
(d) An order issued under this Part shall be served on the owner of the dam as provided in G.S. 1A-1, Rule 4.
(1967, c. 1068, s. 10; 1973, c. 1262, s. 23; 1977, c. 878, s. 3; 1987, c. 827, s. 154; 1993, c. 394, s. 7.)

§ 143-215.33. Administrative hearing.

A person to whom a decision or a dam safety order is issued under this Part may contest the decision or order by filing a contested case petition in accordance with G.S. 150B-23. A person to whom a decision is issued must file a contested case petition within 30 days after the decision is mailed to that person. A person to whom a dam safety order is issued must file a contested case petition within 10 days after the order is served. (1967, c. 1068, s. 11; 1973, c. 1262, s. 23; 1975, c. 842, s. 4; 1977, c. 878, s. 6; 1979, c. 55, s. 2; 1987, c. 827, s. 178; 1993, c. 394, s. 8.)

§ 143-215.34. Investigations by Department; employment of consultants.

The Department shall make such investigations and assemble such data as it deems necessary for a proper review and study of the design and construction of dams, reservoirs and appurtenances, and for such purposes may enter upon private property. The Department may employ or make such agreements with geologists, engineers, or other expert consultants and such assistants as it deems necessary to carry out the provisions of this Part. (1967, c. 1068, s. 12; 1973, c. 1262, s. 23; 1987, c. 827, s. 179.)

§ 143-215.35. Liability for damages.

No action shall be brought against the State of North Carolina, the Department, or the Commission or any agent of the Commission or any employee of the State or the Department for damages sustained through the partial or total failure of any dam or its maintenance by reason of any supervision or other action taken pursuant to or under this Part. Nothing in this Part shall relieve an owner or operator of a dam from the legal duties, obligations and liabilities arising from such ownership or operation. (1967, c. 1068, s. 13; 1973, c. 1262, s. 23; 1987, c. 827, s. 154.)

§ 143-215.36. Enforcement procedures.

(a) Criminal Penalties.

Any person who shall be adjudged to have violated this Article shall be guilty of a Class 3 misdemeanor and shall only be liable to a penalty of not less than one hundred dollars ($100.00) nor more than one thousand dollars ($1,000) for each violation. In addition, if any person is adjudged to have committed such violation willfully, the court may determine that each day during which such violation continued constitutes a separate violation subject to the foregoing penalty.

(b) Civil Penalties.

(1) The Secretary may assess a civil penalty of not less than one hundred dollars ($100.00) nor more than five hundred dollars ($500.00) against any person who violates any provisions of this Part, a rule implementing this Part, or an order issued under this Part.

(2) If any action or failure to act for which a penalty may be assessed under this Part is willful, the Secretary may assess a penalty not to exceed five hundred dollars ($500.00) per day for each day of violation.

(3) In determining the amount of the penalty, the Secretary shall consider the factors set out in G.S. 143B-282.1(b). The procedures set out in G.S. 143B-282.1 shall apply to civil penalty assessments that are presented to the Commission for final agency decision.

(4) The Secretary shall notify any person assessed a civil penalty of the assessment and the specific reasons therefor by registered or certified mail, or by any means authorized by G.S. 1A-1, Rule 4. Contested case petitions shall be filed in accordance with G.S. 150B-23 within 30 days of receipt of the notice of assessment.

(5) Requests for remission of civil penalties shall be filed with the Secretary. Remission requests shall not be considered unless made within 30 days of receipt of the notice of assessment. Remission requests must be accompanied by a waiver of the right to a contested case hearing pursuant to Chapter 150B and a stipulation of the facts on which the assessment was based. Consistent with the limitations in G.S. 143B-282.1(c) and G.S. 143-282.1(d), remission requests may be resolved by the Secretary and the violator. If the Secretary and the violator are unable to resolve the request, the Secretary shall deliver remission requests and his recommended action to the Committee on Civil Penalty Remissions of the Environmental Management Commission appointed pursuant to G.S. 143B-282.1(c).

(6) If any civil penalty has not been paid within 30 days after notice of assessment has been served on the
violator, the Secretary shall request the Attorney General to institute a civil action in the Superior Court of any county in which the violator resides or has his or its principal place of business to recover the amount of the assessment, unless the violator contests the assessment as provided in subdivision (4) of this subsection. If any civil penalty has not been paid within 30 days after the final agency decision or court order has been served on the violator, the Secretary shall request the Attorney General to institute a civil action in the Superior Court of any county in which the violator resides or has his or its principal place of business to recover the amount of the assessment. A civil action shall be filed within three years of the date the final agency decision was served on the violator.

(7) The Secretary may delegate his powers and duties under this section to the Director of the Division of Land Resources of the Department.

(c) Injunctive Relief. - Upon violation of any of the provisions of this Part, a rule implementing this Part, or an order issued under this Part, the Secretary may, either before or after the institution of proceedings for the collection of the penalty imposed by this Part for such violations, request the Attorney General to institute a civil action in the superior court of the county or counties where the violation occurred in the name of the State upon the relation of the Department for injunctive relief to restrain the violation or require corrective action, and for such other or further relief in the premises as said court shall deem proper. Neither the institution of the action nor any of the proceedings thereon shall relieve any party to such proceedings from the penalty prescribed by this Part for any violation of the same. (1967, c. 1068, s. 14; 1973, c. 1262, s. 23; 1975, c. 842, s. 3; 1977, c. 771, s. 4; 1987, c. 827, ss. 154, 180; 1989 (Reg. Sess., 1990), c. 1036, s. 5; 1991, c. 342, ss. 10, 11; 1993, c. 394, s. 9; c. 539, s. 1021; 1994, Ex. Sess., c. 24, s. 14(c).)

§ 143-215.37. Rights of investigation, entry, access, and inspection.

The Commission shall have the right to direct the conduct of such investigations as it may reasonably deem necessary to carry out its duties prescribed in this Part, and the Department shall have the right to conduct such investigations, and for this purpose the employees of the Department and agents of the Commission have the right to enter at reasonable times on any property, public or private, for the purpose of investigating the condition, construction, or operation of any dam or associated equipment facility or property, and to require written statements or the filing of reports under oath, with respect to pertinent questions relating to the construction or operation of any dam: Provided, that no person shall be required to disclose any secret formula, processes or methods used in any manufacturing operation or any confidential information concerning business activities carried on by him or under his supervision. No person shall refuse entry or access to any authorized representative of the Commission or Department who requests entry for purposes of inspection, and who presents appropriate credentials, nor shall any person obstruct, hamper or interfere with any such representative while in the process of carrying out his official duties. (1967, c. 1068, s. 15; 1973, c. 1262, s. 23.)
E.33. North Dakota
61-03-21. State engineer may require plan of operation - Adequate structure. Every operator of a water storage reservoir in North Dakota having a capacity of more than one thousand acre-feet [1233481.84 cubic meters] shall annually, between the first and fifteenth day of February, file with the state engineer an operating plan for such reservoir for the calendar year in which the same is filed. The operator of any such reservoir shall be required to cooperate with the state engineer to the end that all water releases shall be compatible with the best interest of the greatest number of downstream water users and affected landowners. In the event that the state engineer declares an emergency to exist in connection with the operation of any such reservoir, the operator thereof shall promptly submit to the state engineer a separate interim operating plan therefor in addition to the annual reservoir operating plan herein required. Such interim operating plan shall then be coordinated and integrated with the suggestions and plans of the state engineer to best serve the affected interests during such emergency. The state engineer may also require such operators to maintain adequate structures and to operate them in a manner that will prevent waste, promote the beneficial use of water and not endanger the general health and welfare of persons affected thereby. In the event such operator fails to maintain and operate adequate structures in the manner provided in this section, the state engineer shall set a place and time for hearing and shall serve notice upon such operator to show cause at such time and place why his water permit should not be declared terminated and canceled. A copy of any order terminating or canceling such water right shall be filed in the office of the recorder in the county or counties where the land to which the right is appurtenant is located. An appeal may be taken from the decision of the state engineer in accordance with the provisions of chapter 28-32.


61-03-21.1. Inspection by state engineer. Whenever the state engineer is authorized or mandated by law to inspect or investigate an alleged violation of a statute under this title, the state engineer shall have the authority to enter upon land for the purposes of conducting such an inspection or investigation. Except in emergency situations as determined by the state engineer, the state engineer shall request written permission from the landowner to enter the property. If the landowner refuses to give written permission, or fails to respond within five days of the request, the state engineer may request the district court of the district containing the property for an order authorizing the state engineer to enter the property to inspect or investigate the alleged violation.

61-03-21.2. Removal or modification of unsafe or unauthorized works. If the state engineer pursuant to the state engineer's authority under this title determines that works are unsafe or unauthorized, the state engineer shall notify the landowners by registered mail at the landowner's last known post-office address of record. A copy of the notice must also be sent to any tenant, if the state engineer has actual knowledge of the fact that a tenant exists. The notice must specify the nature and extent of the noncompliance, the modifications necessary for compliance, and must state that if the works are not modified or removed within the period stated in the notice, but not less than thirty days, the state engineer shall cause the removal or modification of the works and assess the cost thereof, or such portion as the state engineer shall determine, against the property of the landowner responsible. The notice must also state that the affected landowner may, within fifteen days of the date the notice is mailed, demand, in writing, a hearing upon the matter. The request for a hearing must state with particularity the issues, facts, and points of law to be presented at the hearing. If the state engineer determines the issues, facts, and law to be presented are well founded and are not frivolous and the request for a hearing was not made merely to interpose delay, the state engineer shall set a hearing date without undue delay. In the event of an emergency, the state engineer may immediately apply to the appropriate district court for an injunction prohibiting the landowner or tenant from constructing or maintaining the works, or ordering the landowner to remove or modify the works. Any assessments levied under the provisions of this section must be collected in the same manner as other assessments authorized by this title. If, in the opinion of the state engineer, more than one landowner or tenant has been responsible, the costs may be assessed on a pro rata basis in proportion to the responsibility of the landowners. Any person aggrieved by action of the state engineer under the provisions of this section may appeal the decision of the state engineer to the district court of the county in which the land is located in accordance with the procedures provided under chapter 28-32. A hearing as provided for in this section is a prerequisite to an appeal, unless the hearing was denied by the state engineer.

For purposes of this section, the term "works" includes dams, dikes, wells, or other devices for water conservation, flood control, regulation, storage, diversion, or carriage of water.

CHAPTER 61-04
APPROPRIATION OF WATER

61-04-11. Inspections of works. If the state engineer, in the course of the state engineer’s duties, shall find that any works used for the storage, diversion, or carriage of water are unsafe and a menace to life or property, the state engineer at once shall notify the owner or the owner’s agent, specifying the changes necessary and allowing a reasonable time for putting the works in safe condition. Upon the request of any party, accompanied by the estimated cost of inspection, the state engineer shall cause any alleged unsafe works to be inspected. If they shall be found unsafe by the state engineer, the money deposited by such party shall be refunded, and the fees for inspection shall be paid by the owner of such works. If such fees are not paid by the owner of such works within thirty days after the decision of the state engineer, they shall be a lien against any property of such owner, and shall be recovered by a suit instituted by the state’s attorney of the county at the request of the state engineer. The state engineer, when in the state engineer’s opinion it is necessary, may inspect any works under construction for the storage, diversion, or carriage of water, and may require any changes necessary to secure their safety. The fees for such inspection shall be a lien on any property of the owner and shall be subject to collection as provided in this chapter but neither the United States nor the state of North Dakota nor any agency thereof shall be required to pay such fees.

History: Enacted 1905; amended 1961.

CHAPTER 61-16.1
OPERATION OF WATER RESOURCE DISTRICTS

61-16.1-38. Permit to construct or modify dam, dike, or other device required - Penalty - Emergency. No dikes, dams, or other devices for water conservation, flood control regulation, watershed improvement, or storage of water which are capable of retaining, obstructing, or diverting more than fifty acre-feet [61674.08 cubic meters] of water or twenty-five acre-feet [30837.04 cubic meters] of water for a medium-hazard or high-hazard dam, may be constructed within any district except in accordance with the provisions of this chapter. An application for the construction of any dike, dam, or other device, along with complete plans and specifications, must be presented first to the state engineer. Except for low-hazard dams less than ten feet [3.05 meters] in height, the plans and specifications must be completed by a professional engineer registered in this state. After receipt, the state engineer shall consider the application in such detail as the state engineer deems necessary and proper. The state engineer shall refuse to allow the construction of any unsafe or improper dike, dam, or other device which would interfere with the orderly control of the water resources of the district, or may order such changes, conditions, or modifications as in the judgment of the state engineer may be necessary for safety or the protection of property. Within forty-five days after receipt of the application, except in unique or complex situations, the state engineer shall complete the state engineer’s initial review of the application and forward the application, along with any changes, conditions, or modifications, to the water resource board of the district within which the
contemplated project is located. The board thereupon shall consider, within forty-five days, the application, and suggest any changes, conditions, or modifications to the state engineer. If the application meets with the board's approval, the board shall forward the approved application to the state engineer. The state engineer shall make the final decision on the application and forward that decision to the applicant and the local water resource board. The state engineer may issue temporary permits for dikes, dams, or other devices in cases of an emergency. Any person constructing a dam, dike, or other device, which is capable of retaining, obstructing, or diverting more than fifty acre-feet [61674.08 cubic meters] of water or twenty-five acre-feet [30837.04 cubic meters] of water for a medium-hazard or high-hazard dam, without first securing a permit to do so, as required by this section, is liable for all damages proximately caused by the dam, dike, or other device, and is guilty of a class B misdemeanor.

89-08-01-01. Definitions. The following definitions apply in this article:

1. "Appurtenant works" means all works incident or attached to a dam, dike or other device, including but not limited to:
   a. A spillway, either in the dam or separate from it;
   b. The reservoir and its rim;
   c. A low-level outlet; and
   d. A water conduit such as a tunnel, pipeline, or penstock, either through the dam, dike or other device or their abutments.

2. "Construction" or "construct" means any activity for which a permit is required by North Dakota Century Code section 61-16.1-38, including construction, alteration, enlargement, or modification of a dam, dike, or other device.

3. "Dam" means any artificial barrier or obstruction, including any appurtenant works, across a stream channel, watercourse, or an area that drains naturally or may impound water.

4. "Dike" means an embankment, including appurtenant works, constructed to protect real or personal property.

5. "District" means a water resource district.

6. "Engineer" means a person who has been duly registered and licensed as an engineer by the North Dakota state board of registration for professional engineers and land surveyors.

7. "Height" means the vertical distance in feet from the stream channel bottom at the centerline of the dam to the top of the settled embankment.

8. "High-hazard dam" means any dam located upstream of developed or urban areas where failure may cause serious damage to homes, industrial and commercial buildings, and major public utilities. There is potential for the loss of more than a few lives if the dam fails.
9. "Inspection" means a visual or mechanical check, a measurement, a boring, or any other method necessary for determination of the adequacy of construction techniques, conformity of work with approved plans and specifications, or the safety and operating performance of a dam, dike, or other device.

10. "Low-hazard dam" means a dam located in rural or agricultural areas where there is little possibility of future development. Failure of low-hazard dams may result in damage to agricultural land, township and county roads, and farm buildings other than residences. No loss of life is expected if the dam fails.

11. "Medium-hazard dam" means a dam located in predominately rural or agricultural area where failure may damage isolated homes, main highways, or railroads, or cause interruption of minor public utilities. The potential for the loss of a few lives may be expected if the dam fails.

12. "Other device" means a water control structure, other than a dam or dike, which may include, but is not limited to, diversion ditches, dugouts, lagoons, and holding ponds.

13. "Owner" means any person who owns, controls, operates, maintains, manages, or proposes to construct a dam, dike, or other device, except that for the purpose of signing the application for construction permit, "owner" means the person who owns the property or interest in property upon which the dam, dike, or other device will be built.

14. "State engineer" means the state officer provided for in North Dakota Century Code section 61-03-01 or any of the state engineer's employees or authorized agents.

**History:** Effective November 1, 1989.
**General Authority:** NDCC 28-32-02, 61-03-13
**Law Implemented:** NDCC 61-16.1-38

89-08-01-02. Definition of unsafe dam, dike, or other device. A dam, dike, or other device is unsafe if it threatens harm to life or property, or is improperly maintained.

**History:** Effective November 1, 1989.
**General Authority:** NDCC 28-32-02, 61-03-13
**Law Implemented:** NDCC 61-03-21.2
CHAPTER 89-08-02
CONSTRUCTION PERMITS

89-08-02-01. Determining the capacity of dams, dikes, or other devices. The impounding capacity of a dam is calculated based upon the top of the settled embankment of the dam. The diverting capacity of a dike is calculated based upon the area protected as measured from the top of the dike. If the absence of the dike could result in more than fifty acre-feet of water inundating the protected area, a permit is required. The diverting capacity of a diversion ditch is calculated based upon the runoff from a twenty-five year, twenty-four hour, precipitation event. No construction on the dam, dike, or other device can begin until a construction permit is obtained.

History: Effective November 1, 1989; amended effective April 1, 2004.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-16.1-38

89-08-02-02. Contents of application. A completed application for a construction permit must be submitted to the state engineer along with plans and specifications; evidence recognized in a court of law sufficient to establish a prima facie case of a property right in the property that will be affected by the construction of the dam, dike, or other device; and any additional data or information required by the state engineer.

History: Effective November 1, 1989; amended effective June 1, 1998; April 1, 2004.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-16.1-38

89-08-02-03. Permit does not absolve liability for damages. The receipt of a permit, including a permit for emergency construction, does not relieve an applicant from liability for damages resulting from any activity conducted pursuant to the permit.

History: Effective June 1, 1998.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-16.1-38

89-08-02-04. Temporary construction permits. If the state engineer determines an emergency exists, the state engineer may issue a temporary permit to construct a dam, dike, or other device capable of impounding, obstructing, or diverting more than fifty acre-feet. A temporary permit shall have a duration of not more than six months unless extended by the state engineer.

History: Effective April 1, 2004.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-16.1-38
CHAPTER 89-08-03
INSPECTIONS

89-08-03-01. Inspections and reports during construction of high-hazard dams, medium-hazard dams, and low-hazard dams over ten feet [3.05 meters] in height. In order to protect property and assure safety, the following are conditions to all permits for high-hazard dams, medium-hazard dams, or low-hazard dams over ten feet [3.05 meters] in height:

1. An engineer must be in charge of and responsible for inspections during construction.

2. Inspections during construction must be performed at intervals necessary to ensure conformity with the construction permit and the plans and specifications.

3. Within seven days after each inspection, the engineer in charge shall submit a written report to the state engineer specifying the information obtained pursuant to the inspection. The report will specify any changes necessary under this section.

History: Effective November 1, 1989; amended effective April 1, 2004.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-16.1-38

89-08-03-02. Monitoring during construction by the state engineer. The state engineer may monitor any dam, dike, or other device during construction to ensure conformity with the construction permit and the plans and specifications.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-04-11

89-08-03-03. Changes in construction. If, pursuant to an inspection under section 89-08-03-01 or section 89-08-03-02, the state engineer or engineer in charge determines changes in construction are necessary to insure safety, whether the changes are necessary because the dam, dike, or other device does not comply with the construction permit or plans and specifications, or an unforeseen condition is discovered, or for any other reason, the state engineer may order the appropriate changes and may order construction be stopped until the changes are made.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-04-11
89-08-03-04. Requested inspections.

1. Upon receipt of an affidavit complaining a dam, dike or other device is unsafe because of its construction, maintenance, or operation, the state engineer shall examine the available information and determine if the complaint is justified.

2. If the state engineer determines the complaint is unjustified, the state engineer shall notify the complainant in writing of that fact. If the complainant continues to request an inspection even though the state engineer determines the complaint is unjustified, the state engineer shall make the inspection upon receiving from the complainant a certified check or cashier's check in an amount sufficient to cover the total cost of inspection.

3. If the state engineer determines the complaint is justified, the state engineer shall make the inspection upon receiving from the complainant a certified check or cashier's check in an amount sufficient to cover the total cost of inspection.

4. If the dam, dike, or other device is defective, the state engineer shall require the owner of the dam, dike, or other device to pay the cost of inspection, and upon payment shall return the amount deposited by the complainant. If the cost of inspection is not paid within thirty days by the owner of the defective dam, dike, or other device, the cost of inspection shall become a lien against any of the owner's property.

5. If the dam, dike, or other device is not found defective, any money deposited by the complainant for the inspection may not be returned.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-04-11, 61-03-21.1, 61-03-21.2

89-08-03-05. Periodic inspections after construction. As a condition on all construction permits, the state engineer may require inspection of a dam, dike, or other device as often as necessary after construction to protect property and assure safety.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-04-11, 61-16.1-38
89-08-03-06. As built plans. As a condition on all construction permits, the owner of the dam, dike, or other device will provide the state engineer with "as built" plans after the dam, dike, or other device has been constructed.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-16.1-38
CHAPTER 89-08-04
OPERATING PLAN

89-08-04-01. Operating plan. By the fifteenth of February of each year, the operator of a reservoir with a capacity of more than one thousand acre-feet shall submit an operation plan for that year to the state engineer. The state engineer shall review the operating plan and if deficiencies or discrepancies exist, the state engineer shall notify the owner of the dam of the deficiencies or discrepancies within thirty days of discovering the deficiencies or discrepancies. The owner of the dam shall correct the deficiencies or discrepancies and return the corrected operating plan to the state engineer within fourteen days of receiving notice of the deficiencies or discrepancies. The operation plan must be approved by the state engineer prior to the operation of the dam. If the operator receives no response from the state engineer, the operation plan is approved. The operation plan must contain at a minimum:

1. A reservoir operation procedure;

2. A maintenance procedure for the dam and appurtenant works; and

3. Emergency procedures and warning plans.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-03-21
North Dakota
Dam Design Handbook

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SECOND PRINTING

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This handbook represents a multi-agency effort at incorporating specific standards for dam design in North Dakota. The following individuals and agencies participated in writing and/or review of the handbook. Their contributions are greatly appreciated.

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CHAPTER I:

Purpose and Authority of Manual

The North Dakota State Engineer, under Section 61-02-14 of the North Dakota Century Code (NDCC), is charged with reviewing and approving construction drawings and specifications for dams constructed in North Dakota.

This handbook is primarily for use by engineers in the design and construction of earth dams in the state of North Dakota. Water resource districts may also find the handbook of assistance in their work. The handbook is a guide for the gathering of data, the design of the structure, the preparation of construction drawings and specifications, and the inspection of construction.

The handbook is not to be considered and does not represent a comprehensive step-by-step set of requirements for dam design. Its purpose is to outline the suggested standards for dam design in North Dakota, along with recommended methods and references. The engineering for each dam will be reviewed by the State Engineer on a case-by-case basis. Latitude will be provided to engineers allowing use of other methods producing a product of satisfactory quality.

CHAPTER II:

Liability

As a general rule, engineers have a duty to "exercise that degree of skill and knowledge normally exercised by members of the profession."

A design professional who plans and supervises a construction project will be liable to all persons who may foreseeably be injured if he does not fulfill his duty of properly exercising the skill he is assumed to possess. Design engineers have been found liable to the contractor, and to workmen for damages caused by defects in a design, if an exercise of the proper degree of skill would have prevented the defect.

Section 9-08-02.1 of the NDCC voids construction contracts with provisions making the contractor liable for "errors or omissions of the owner or his agents in the plans and specifications." Under this statute, the design professional will likely be either an owner or an owner's agent. Attempts to pass the liability for design defects to the contractor generally have been ineffective.

Owners of dams have a continuing duty to maintain their dams in a safe and hazard-free condition. Their duty also applies to the area adjacent to the dam. Liability may result if it is determined that injury or damages occurred as a result of an owner's negligence in maintaining a dam.

Section 43-19.1-28 of the NDCC requires the state or any political subdivision (including water resource boards, commissions, etc.) to hire a registered professional engineer to make all engineering drawings, specifications, estimates, and to supervise construction if the cost of the project exceeds $50,000.
CHAPTER III:

Permit Requirements

A. Authority
The North Dakota State Engineer, pursuant to Chapter 61-04 and Sections 61-16.1-38 and 61-16.1-53, North Dakota Century Code, and the North Dakota State Water Commission, pursuant to Section 61-02-14 of the North Dakota Century Code, have the power, authority and general jurisdiction to regulate, control and supervise the construction and operation of all dams within the state of North Dakota, both public and private, which they deem necessary or advisable. Also, the State Water Commission has the power and authority to work with the United States and any of its departments, agencies or officers with regard to dams, and to do what is necessary to carry out the expressed and implied purposes of Chapter 61-02, North Dakota Century Code.

B. Permits
1. Construction Permit
No dams which are capable of retaining or storing more than 12½ acre-feet of water may be constructed in North Dakota without a permit. An application for the construction of a dam must be submitted first to the State Engineer. The application must be on State Water Commission Form 110 (see Appendix A) and must include complete plans and specifications for the dam or reference to standard specifications. Upon receipt, the State Engineer will review the application. Except in unique circumstances, the State Engineer will complete his initial review within 45 days. He will forward the application, plans and specifications, along with any changes or conditions, to the water resource board of the district within which the contemplated dam is located. Within 45 days, the board shall consider the application and information forwarded by the State Engineer and return it to the State Engineer with its decision and comments regarding suggested changes, conditions and modifications. The State Engineer makes the final decision and forwards that decision to the applicant and the board (61-16.1-38, N.D.C.C.).

2. Water Permit
If water is to be appropriated and put to beneficial use as a result of the construction of a dam, a conditional water permit must be obtained prior to the initiation of construction. An application form 108 (see Appendix A) and instruction booklet, for the purpose of acquiring a conditional water permit, may be obtained from the State Engineer’s office in Bismarck, Chapter 61-04, NDCC, establishes the procedures that must be followed prior to acquiring a conditional water permit.

3. Other Permits
The construction of a dam may require several other permits. The Corps of Engineers may require permits under the authority of Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. The North Dakota Health Department requires a permit to discharge water into a stream. The State Engineer also requires a temporary water permit for water used during construction. Additional information on these permits can be obtained by contacting the respective agencies.
CHAPTER IV:

Classification of Dams

Dams shall be categorized according to the potential hazard to property or loss of life if the dam should suddenly fail. Existing development, as well as future downstream development, must be considered when categorizing a dam. The hazard category will be based solely on potential hazard from failure and not on the selected design criteria.

Although it is recognized that loss of life is possible with any dam failure, the following hazard categories of dams have been established for North Dakota:

**Low** — dams located in rural or agricultural areas where there is little possibility of future development. Failure of low hazard dams may result in damage to agricultural land, township and county roads, and farm buildings other than residences. No loss of life is expected if the dam fails;

**Medium** — dams located in predominantly rural or agricultural areas where failure may damage isolated homes, main highways, railroads or cause interruption of minor public utilities. The potential for the loss of a few lives may be expected if the dam fails;

**High** — dams located upstream of developed and urban areas where failure may cause serious damage to homes, industrial and commercial buildings and major public utilities. There is a potential for the loss of more than a few lives if the dam fails.

After a dam has been categorized according to failure hazard, it will also be classified for dam design criteria. Design criteria shall be based on the hazard classification and the height of the dam. ("Height of the dam" is defined as the distance in feet from the stream channel bottom at the centerline of the dam to the top of the settled embankment.)

Table 4-1 is based on dam height and hazard categories and outlines five classifications for dam design. Each classification will require varying degrees of intensity of investigation for hydrology, foundation and borrow explorations, soil testing, structural design, etc.

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CHAPTER V:

Standards for New Earthfill Dams

In general, earth dams should be designed in accordance with the following principles:

- the embankment shall not be overtopped by the design flood;
- the embankment phreatic line will not intercept the downstream face;
- the embankment slopes are stable under varying conditions;
- the embankment slopes are flat enough to limit shear stress in the foundation to the shear strength of the foundation materials with an adequate factor of safety;
- seepage water will not pass freely from the upstream embankment face to the downstream embankment face;
- seepage water passing through the embankment or the foundation shall have velocities lower than that required to move embankment or foundation materials; and
- the upstream face is protected against wave action and erosion and the downstream face is protected against erosion.

The criteria standards listed in this chapter are commensurate with the design classifications listed in Chapter IV. Thus, a low hazard dam will not require as extensive an investigation as a high hazard dam. It is recommended that the designer prepare a preliminary outline for review by the State Engineer prior to submitting the permit application. The outline shall set forth the dam classification, the general criteria to be used, and the degree of investigation and testing determined appropriate in the design of the proposed dam. The outline shall give the location, purpose, drainage area, owner, etc., of the proposed structure. The furnishing of this outline may eliminate unnecessary investigation expense.

This chapter is divided into eight sections, each covering a major component in the design of a dam. Each section includes a discussion of the general considerations along with suggested criteria standards. The majority of the suggestions are USDA-Soil Conservation Service criteria and guidelines with modifications. Deviations from these recommendations may be allowed, subject to the approval of the State Engineer, if there is a sound engineering basis for the change. The eight main sections in this chapter include:

- A. Land Rights and Utilities
- B. Hydrology
- C. Sediment Storage
- D. Geotechnical Exploration
- E. Embankment and Foundation Design
- F. Principal Spillway Design
- G. Emergency Spillway Design
- H. Design Documentation

A. Land Rights and Utilities

1. Land Rights

The need for fee title, easements and construction permits largely depends on the present and future ownership of the land involved in the dam and reservoir area. In general, stock and small irrigation dams are on the dam owner's land. In this case, land rights are usually unnecessary unless prior easements exist for other purposes. Larger dams, reservoirs and borrow areas may be located on land of several owners.

While it is the responsibility of the structure owner to obtain the necessary fee title, easements or construction permits, it is recommended that the designer prepare a land rights map for the owner and the State Engineer showing:

(a) the location of the structure (section, township, and range) on a county map which also shows prominent landmarks;
(b) a detailed site layout map showing both the land ownership, and the location of the dam, reservoir, borrow area(s) and ingress and egress routes (section, subdivisions, township and range);
(c) farmsteads and buildings;
(d) public roads;
(e) surface and buried utilities; and
(f) mines, oil wells, gravel pits, etc.

2. Utilities

Existing pipelines, cables, conduits, and materials are frequently encountered in proposed reservoir areas. Buried conduits are usually located at shallow depths in the floodplain. Utilities that represent a safety hazard should be relocated away from the site or modified to provide adequate safety assurances. Overhead cables or power lines should be relocated or raised as necessary to prevent damage or hazard to the public. All land rights, including subordination easements, should be obtained prior to bid letting or construction.

Every reasonable effort should be made to remove all conduits, cables and pipelines from the site. Most utility owners will want their facility removed from the site for easy maintenance. Only as a last resort, and
with concurrence of the affected utility owner and State Engineer, are conduits to be permitted to remain under an earthen embankment.

Conduits permitted to remain under any part of the embankment are to be: (1) encased in concrete or otherwise treated to ensure durability and strength equal to that of the principal spillway; (2) properly articulated on all yielding foundations; (3) made watertight against leaking either into or out of the conduit; and (4) provided with anti-seep collars.

Enclosure of a conduit in another conduit is acceptable if the larger conduit meets the requirements of this section. The outside conduit must be positively sealed at the upstream end to prevent seepage and must extend the full distance under the embankment.

All plans for leaving utilities under the embankment or reservoir areas of a dam must have the approval of the utility owner and appropriate regulatory agencies.

B. Hydrology

One aspect in the investigation of a dam is the determination of the hydrologic performance of the project during flood events. These hydrologic investigations can usually be placed in two classes: (1) the investigations based on specific frequencies to determine the size of the principal spillway, and (2) the investigations based on Probable Maximum Precipitation (PMP) to determine the size of the emergency spillway. This section describes the procedures recommended for determining the required sizes of these spillways.

1. Drainage Area Determination
   (a) Principal Spillway Design
      The contributing drainage area for principal spillway design can be adjusted for significant storage areas within the watershed. The available depressional storage may be estimated by a number of methods including field reviews, USGS topographic maps and aerial photography. It is recommended that 5-10 percent of the storage areas be randomly sampled to determine their approximate surface areas and depths. These samples should indicate both normal water levels and levels to the point of overflow. Normal water levels should be verified by landowner interviews or by examination of photographic records. Using this surface area and depth information, the volume of available storage may be estimated. If the volume of storage is large in relation to the design runoff volume, the storage areas may be considered non-contributing and may be deducted from the drainage area used to develop the design flood hydrograph for the principal spillway. Although the determination of significant storage is a judgment decision, storage should be at least 70 percent of the design runoff volume before areas are classified as non-contributing. Times of concentration and other watershed parameters should be based only on the contributing area.
   (b) Emergency Spillway Design
      The design storms for emergency spillway and freeboard design are critical to the safety of the dam. Also, runoff volumes are typically large, approaching the probable maximum values for high hazard structures. Because depressional storage areas may be periodically full, or partially full, reduction of the drainage area and associated runoff amounts are not recommended for the emergency spillway and freeboard design storms. Therefore, the total drainage area should be used for these design storms.

2. Rainfall and Snowmelt Design Data
   Generally, principal spillway capacity and associated floodwater retarding storage is designed to meet the objectives of the dam; emergency spillway capacity is designed to provide the necessary safety requirements of the dam. The precipitation design amount used to size these spillways is related to the dam design classifications. Table 5-1 shows the suggested hydrologic spillway criteria for both the principal and emergency spillways.

As indicated by footnote 3, Table 5-1, the State Engineer may allow adjustments to the PMP events on a case-by-case basis. One method that could be used to evaluate downstream impacts is risk analysis. Risk analysis can involve an assessment of several factors including incremental damage, depth of inundation in the downstream area and the opportunity to warn downstream areas. Incremental damage is the difference in damages, including loss of life, between two or more conditions. For example, incremental damage would be the difference in damages caused by a PMP event with a dam failure and the damages caused by a PMP event without a dam failure. The depth of inundation in the downstream area, including velocities, also emerges as an important factor to consider. In North Dakota, most natural floods do not produce high velocities in the inundation areas. These lower velocities reduce the risk of loss of life and, to some extent, loss of property. However, water depths and velocities resulting from a dam failure will likely be very high and, therefore, need careful review. The opportunity to warn downstream areas of a

| Table 5-1. Suggested Precipitation Criteria For Spillway Design | 1 2 3 |
|---|---|---|---|---|
| Dam Design Classification | Principal Spillway | Emergency Spillway | Velocity | Freeboard |
| I | -- | P10 | P25 | P35 |
| II | -- | P25 | P35 | P55 |
| III | P25 | P35 | .3 PMP | .5 PMP |
| IV | P25 | .3 PMP | .5 PMP | PMP |
| V | P100 | .4 PMP | PMP | |

1 Precipitation amounts by return period in years.
2 PMP = Probable Maximum Precipitation.
3 Each dam will have to be carefully evaluated to determine potential impact of dam failure. If the design engineer can show that damages and loss of life would not be significant as a result of failure, the State Engineer may allow a smaller event as the acceptable criteria.
4 See Table 4-1, page 3.
5 The requirement of the principal spillway event is to pass the flows without use of a non-structural emergency spillway.
6 The requirement of the velocity hydrograph is to pass the flows within acceptable velocity limits (See Table 5-2, page 6).
7 The requirement of the freeboard hydrograph is to pass the flows without overtopping the dam.
dam failure is also important. If the main impact area is only a few miles downstream, the amount of time available to warn people is short. On the other hand, the time available to warn areas 10 or 20 miles downstream is longer, therefore, the loss-of-life factor will be reduced. The development of a good warning system can significantly reduce loss-of-life impacts.

It is possible that an embankment can withstand overtopping without failing. This may be due to design features, construction methods and materials, and limited depth and duration of overtopping. If it can be shown that overtopping is not likely to result in the failure of the dam, then a smaller design event may be allowed.

(a) Principal Spillway Precipitation

The principal spillway precipitation events are used to determine the capacity of the principal spillway and the minimum elevation of the emergency spillway. Rainfall and snowmelt frequencies for design events of 100-year or less can be found in the USDA-SCS “North Dakota Hydrology Manual.” The SCS soil cover complex number (curve number) procedure found in the manual is recommended for determining runoff volumes from rainfall precipitation.

Estimates of direct runoff volumes for design can be found in Soil Conservation Service’s Technical Release Number 60, “Earth Dams and Reservoirs,” and in the “North Dakota Hydrology Manual.” Referenced volumes are for a 10-day duration and are used in the development of a principal spillway hydrograph.

The event that provides the maximum reservoir level should be used as the design event (i.e., 24-hour rainfall, 10-day rainfall or snowmelt). The critical event is dependent on the storage capacity and design of the dam. The 10-day events are the most common critical events, therefore, they should always be included in the analysis.

The time distribution of the precipitation events is also an important factor. The distribution tables found in the “North Dakota Hydrology Manual” are acceptable.

(b) Emergency Spillway Design Precipitation

The velocity precipitation amounts shown in Table 5-1 are the storm events that must be passed through the emergency spillway at a safe velocity. Allowable velocities depend on soils within the spillway. Table 5-2 lists the permissible velocities for vegetated emergency spillways. The values in Table 5-2 may be increased 10 percent when the anticipated use of the spillway is not more frequent than once in 50 years. They may be increased 25 percent when the anticipated use is not more frequent than once in 100 years. The freeboard precipitation amounts, shown in Table 5-1, are the minimum design storms that the structure must pass without overtopping the embankment. The velocity criteria does not apply to freeboard precipitation.

Hydrologic designs of emergency spillways for dam classifications III, IV and V require a determination of the PMP. These PMP amounts can be found in the U.S. Department of Commerce - National Oceanic and Atmospheric Administration (NOAA) “Hydrometeorological Report,” Number 51.

For class V dams, it is suggested that the procedures outlined in NOAA “Hydrometeorological Report,” Number 52 be followed in determining the Probable Maximum Flood (PMF). For lower class dams, it is adequate to determine the PMP rainfall amounts from the “North Dakota Hydrology Manual,” adjust the amounts according to Table 5-1, and input this information directly into the hydrologic model.

3. Hydrograph Development and Infiltration Techniques

Acceptable procedures for hydrograph development are contained in the USDA-SCS “National Engineering Handbook,” Section 4 - Hydrology. The Snyder and Clark unit hydrographs are also acceptable techniques.

Acceptable procedures for estimating the time of concentrations and the runoff curve numbers are outlined in the “North Dakota Hydrology Manual.” The curve numbers for the 10-day rainfall event may be adjusted as shown in the SCS’s Technical Release Number 60, “Earth Dams and Reservoirs.” These adjustments do not apply to 24-hour and PMP rainfall events. It is recommended that an antecedent moisture condition of II or III be used in the SCS TR-20 computer model.

Base flow should also be included in hydrograph development at all sites where applicable. Base flow

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</tbody>
</table>
amounts will be determined from available stream gage data or from regional data when site specific data are not available.

If a portion of the watershed is developed, or there is potential for development, it is recommended that the SCS's Technical Release Number 55, "Urban Hydrology for Small Watersheds," be used to make appropriate adjustments. This publication outlines procedures for increasing the runoff rates and flow velocities resulting from developed areas.

4. Routing Procedures
The purpose of flood routing is to determine what rate of flow will occur at specific times and locations in a stream or at a structure. There are two general types of flood routing as applied to dam design and evaluation: (1) stream flow routing; and (2) reservoir routing.

Stream flow or channel routing may be accomplished by several methods. The most common routing techniques are Muskingum, the modified pulse, and techniques that use actual channel cross-section data.

Reservoirs can be routed by any number of level pool techniques. The basic requirements include reservoir elevation-storage information and a spillway rating curve. The principal spillway, the emergency spillway and the freeboard hydrographs should be routed through the reservoir with the starting water elevation at the normal water level. The principal spillway should also be adequate to draw down the reservoir pool level to 85 percent of the flood pool storage within a 10-day period. If the pool is not drawn down, the water level at the end of 10 days should be used as the starting water level for the design storm events. This may require an increase in either the spillway capacity or the volume of flood storage.

5. Computer Models
There are several computer models available for the hydrologic analyses in dam design. The Corps of Engineers' HEC-1 model and the SCS's TR-20 and DamS II computer models are recommended. If other models are used, the State Engineer may require model documentation. A hydrologic computer model is required for all design class IV and V dams.

When using a computer model, it is advisable to divide a watershed into subareas on the basis of size, drainage pattern, existing and proposed facilities, vegetation, soil and cover types, channel gradients and precipitation amounts. The subarea flows are connected and combined by channel routing.

It is advisable to calibrate the model results to historical flood events where adequate stream gage data is available. In this manner, the model timing, volume and peak flows can be checked. In areas where stream gage data is not available, it is recommended that alternate techniques be used to calibrate the model.

6. Dam Breach Analysis
Dam breach analysis requires a specific analytical approach rather than the use of procedures described for spillway design. A dam breach model analysis is required of all medium and high hazard dams. The suggested starting water elevation for a dam breach analysis is the elevation of the top of the dam. Although a specific modeling procedure is not required, the National Weather Service Dam Break Flood Forecasting Computer Model is suggested. There are several versions of this model. The SCS's TR-66 model, "Simplified Dam - Breach Routing Procedure," is also available for use.

7. Runoff Yield and Reliability
Where adequate stream gage data are available at a site, estimates will be based on that data. Where stream gage data are not available, it is recommended that estimates be based on procedures outlined in the SCS "North Dakota Hydrology Manual," Chapter VII.

C. Sediment Storage
To assure the full effectiveness of a reservoir, capacity must be provided for sediment accumulation. There are several ways to determine sediment yields or rates of sediment accumulation in reservoirs. Two methods are discussed in this section: (1) the Sediment Delivery Ratio Method, and (2) the Reservoir Sedimentation Surveys Method. In general, the sediment delivery ratio method provides a higher level of sediment accumulation than the survey method. Reservoir sedimentation surveys may provide more accurate data for historical sediment accumulations in North Dakota reservoirs. However, it is advised that for design purposes, the engineer be conservative when using the survey method and apply a suitable factor of safety.

The criteria in this section do not apply to dams constructed as sediment ponds for coal mining operations. Those sediment ponds must be sized in accordance with North Dakota Public Service Commission criteria.

1. Sediment Delivery Ratio Method
The sediment delivery ratio method is well-adapted for estimating current sediment yields and predicting the influence of land treatment measures on future sediment yields. The following equation is employed.

\[ Y = E(DR) \]

Where:
- \( Y \) = sediment yield (tons/acre/year)
- \( E \) = gross erosion (tons/acre/year)
- \( DR \) = sediment delivery ratio (percent)

The gross or total erosion in the drainage area of a reservoir is the summation of all water erosion occurring in the drainage area. It includes sheet and rill erosion, and channel-type erosion (gullies, valley trenches, streambank erosion, etc.). Procedures for the determination of quantitative values for each type of erosion are outlined in existing guides, handbooks, and technical releases. The SCS can provide valuable assistance in computing gross erosion.

The sediment delivery ratio is dependent on the topography, geology, and size of the drainage area. Any structures above the dam site (other dams, bridges, or culverts) that slow the runoff substantially will also affect sediment delivery. The most important variable is the size of the contributing drainage area. Figure 5-1 is a widely used curve depicting the relationship between sediment delivery ratio and drainage area.
Sediment accumulation in a reservoir is dependent on the sediment delivery to the reservoir and on the trap efficiency. How the accumulated sediment will be distributed within the reservoir depends upon the character of the inflowing sediment, the operation of the reservoir, and other factors.

Trap efficiency is the amount (in percent) of sediment delivered to the site that will remain in the reservoir. It is a function of detention storage time, sediment characteristics, inflow characteristics and other factors. Trap efficiency can be estimated (using Figure 5-2) on the basis of the ratio of the reservoir capacity in acre-feet to the average annual inflow in acre-feet.

2. Reservoir Sedimentation Survey Method

Reservoir sedimentation surveys are excellent sources of data for establishing sediment yields to reservoirs. Reservoir deposition and sediment yield are not synonymous. To obtain the sediment yield to a surveyed reservoir, the measured deposition in that reservoir must be divided by its estimated trap efficiency. This takes into account the portion of the sediment inflow that passes through the reservoir and is not deposited. The use of the rate of deposition, established by a sedimentation survey, implies that both the sediment yield rate and the trap efficiency of the reservoir being designed are the same as that of the surveyed reservoir.

Results of available reservoir sedimentation surveys should be reviewed for design purposes. Table 5-3 lists several reservoirs in North Dakota for which sedimentation surveys have been conducted.

If no reservoirs representative of the area have been surveyed, it may be advisable to conduct sedimentation surveys on reservoirs in the area that are at least 10 years old. It is important that the period of sedimentation record be long enough to be representative of average conditions.

It is also important that the history of reservoirs considered for sediment surveys be known. Sediment removal or drying, or changes in spillway elevations affect sediment volume and distribution.

The reservoir drainage areas on which sedimentation surveys have been made for specific sediment design must be similar in topography, soils, and land use to those drainage areas for which information is desired. In addition, if the measured rates are to be applied directly, the size of the drainage areas of the surveyed reservoirs should not be less than one-half nor more than twice that of the structures being designed. For drainage areas outside these limitations, the annual sediment yield may be adjusted for design use on the basis of the drainage areas to the 0.8 power in the following manner:

\[ Y_e = Y_m \left( \frac{A_e}{A_m} \right)^{0.8} \]

Where:
- \( Y_e \) = sediment yield to structure being designed (in tons per year)
- \( Y_m \) = sediment yield to the surveyed reservoir (in tons per year); measured annual deposition + trap efficiency of surveyed reservoir
- \( A_e \) = drainage area of reservoir being designed
- \( A_m \) = drainage area of surveyed reservoir
### Table 5-3. Reservoir Sedimentation Surveys

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>County</th>
<th>Location</th>
<th>Drainage Area (Sq. Mi.)</th>
<th>Sediment (Tons per sq. Mi. per Year)</th>
<th>Sediment (Acre-feet per Year per Sq. Mi.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blabon</td>
<td>Steele</td>
<td>3</td>
<td>145 56</td>
<td>1.22</td>
<td>875.0</td>
</tr>
<tr>
<td>Dougherty</td>
<td>Walsh</td>
<td>31</td>
<td>157 57</td>
<td>20.2</td>
<td>18.8</td>
</tr>
<tr>
<td>Gustafson Bros.</td>
<td>Walsh</td>
<td>23</td>
<td>157 57</td>
<td>3.75</td>
<td>18.8</td>
</tr>
<tr>
<td>Gwinner</td>
<td>Sargent</td>
<td>11</td>
<td>132 56</td>
<td>0.222</td>
<td>372.0</td>
</tr>
<tr>
<td>Northern Pacific Railroad</td>
<td>Cass</td>
<td>25</td>
<td>140 54</td>
<td>12.16</td>
<td>39.6</td>
</tr>
<tr>
<td>Melvin Bellerud</td>
<td>Walsh</td>
<td>26</td>
<td>157 57</td>
<td>1.125</td>
<td>114.7</td>
</tr>
<tr>
<td>Milton WPA Dam</td>
<td>Cavalier</td>
<td>31</td>
<td>160 57</td>
<td>42.4</td>
<td>51.5</td>
</tr>
<tr>
<td>Norby Dam</td>
<td>Sargent</td>
<td>20</td>
<td>129 54</td>
<td>0.183</td>
<td>184.0</td>
</tr>
<tr>
<td>Sioux Railroad Reservoir</td>
<td>Walsh</td>
<td>13</td>
<td>157 57</td>
<td>16.86</td>
<td>18.9</td>
</tr>
<tr>
<td>Bald Hill Dam</td>
<td>Barnes</td>
<td>18</td>
<td>141 58</td>
<td>1,979.0</td>
<td>245.0</td>
</tr>
<tr>
<td>Homme Dam</td>
<td>Walsh</td>
<td>19</td>
<td>157 55</td>
<td>229.0</td>
<td>441.0</td>
</tr>
<tr>
<td>Van Oosting Dam</td>
<td>Oliver</td>
<td>6</td>
<td>143 82</td>
<td>1.76</td>
<td>593.3</td>
</tr>
<tr>
<td>Mount Carmel</td>
<td>Cavalier</td>
<td>28</td>
<td>163 59</td>
<td>61.9</td>
<td>104.5</td>
</tr>
<tr>
<td>Erie Dam (Brewer Lake)</td>
<td>Cass</td>
<td>20</td>
<td>142 53</td>
<td>11.15</td>
<td>392.0</td>
</tr>
<tr>
<td>Kropp Farms Dam</td>
<td>Stutsman</td>
<td>14</td>
<td>141 63</td>
<td>2.77</td>
<td>113.3</td>
</tr>
<tr>
<td>Bossman Irrigation Dam</td>
<td>Golden Valley</td>
<td>2</td>
<td>137 105</td>
<td>37.2</td>
<td>226.5</td>
</tr>
<tr>
<td>Sterling Dam</td>
<td>Burleigh</td>
<td>4</td>
<td>138 76</td>
<td>23.87</td>
<td>33.4</td>
</tr>
<tr>
<td>Upper Turtle Watershed Detention Dam #6</td>
<td>Grand Forks</td>
<td>23</td>
<td>152 56</td>
<td>11.18</td>
<td>34.9</td>
</tr>
</tbody>
</table>

2. USDA, Soil Conservation Service, Carlson, Car. 

### D. Geotechnical Exploration

Geotechnical explorations of potential dam sites must be adequate to determine: (1) the suitability of the foundation and abutments for an earthfill embankment and reservoir; (2) the foundation treatment (preparation) measures required; (3) the excavation slopes of the cutoff trench; (4) the embankment design; and (5) the availability and characteristics of the borrow area materials for the embankment. The explorations should include classification of soils, determination of physical properties, location and extent of soil and rock strata and the variations in ground water levels.

The magnitude of the geotechnical exploration program is governed principally by the complexity of the foundation problems and the design classification of the project. Generally, design class I and II dams may only require two or three augered holes along the centerline of the dam, and two or three augered holes in the proposed borrow area and/or emergency spillway. The centerline auger holes should be 10 or more feet deep, depending on the materials encountered. Usually, no samples are taken and the materials are field classified. If problems are detected, a more extensive program should be undertaken.

Design class III, IV, and V dams require detailed geotechnical explorations. In the preliminary stages of these projects, reconnaissance surveys are undertaken to determine the general suitability of the potential dam sites. The reconnaissance surveys are often completed on several dam locations to determine the most suitable sites. The detailed surveys are made to determine the final dam location and, as quantitatively as possible, determine the geologic conditions that will be encountered during construction.

1. **Reconnaissance Surveys**

To determine the most suitable site for a dam, reconnaissance surveys are made. These surveys consist of a review of existing geologic information and a visit to the site by an experienced geologist or engineer. The survey normally does not include exploration drilling. The reconnaissance survey is aimed at determining topographically suitable locations and determining the limits of the exploration program. The most common sources of existing information are 7½ minute topographic quadrangle maps, county ground water reports, detailed soils survey reports, aerial photographs and other relevant reports.

The general physiographic features that should be noted include the shapes and types of valleys, the gradients and stages of erosion development, and the terraces (if present along with the valleys). The origin of the terraces is significant, regardless of whether they result from uplift, meandering, structural control, glaciation or landslide.

Observations of ground-water conditions should be recorded. Springs, wells, ephemeral streams, swamps, or other evidences of ground water aid in establishing the water table and the effects of ground water in the area. The reservoir area and road cuts in the vicinity should be examined for stability and strata identification.

2. **Detailed Surveys**

Reconnaissance commonly brings to light defects disqualifying some of the sites. As the next step, detailed studies are conducted at the more favorable sites. These studies must determine whether there are geological conditions that will affect the stability and
success of the dam and whether these conditions will require special design considerations during foundation preparation and construction.

At this stage of the examination, preliminary cross sections of the valley at potential dam sites should be surveyed and plotted. The drawing of the cross sections may show where more geologic information is needed.

After the surficial explorations, a drilling program can be planned to obtain supplemental geological data. The location of drill holes can also be determined to obtain maximum information. Field exploration is often completed in phases, with the data analyzed between each drilling phase.

A systematic search for suitable construction material for the dam is an important part of the survey. Because of the large volume required for most projects, long haul distances might be prohibitively expensive. Pits and other locations of filter material and riprap should be inventoried, both qualitatively and quantitatively.

3. Soil Classification

Knowledge of soil classification, including typical engineering properties of soil groups, is especially valuable when prospecting for earth materials or investigating foundations for structures. When adequate safety factors are provided, proper soil classification can be used to estimate numerical values of engineering characteristics of soils for use in small dams.

The Unified Soil Classification System is recommended for use in the design and construction of dams. Figure 5-3, the Unified Soil Classification Chart, gives the essentials of the classification system for soils.

In addition to proper classification, it is important to include an adequate description of the soil in reports or logs of explorations. The classification chart contains the information required for describing soils, citing several examples.

4. Sampling

The purposes and uses of samples are numerous. They are required to properly identify and classify soil or rock. They are essential for field density and moisture determinations. Samples are also used in laboratory tests of earth materials, concrete aggregate, filter material, and riprap. To a large degree, samples document the results of explorations for foundations, abutments and construction materials for dams. Obviously, erroneous conclusions will be drawn if the samples are not truly representative of the explorations.

Samples are broadly classified as disturbed or relatively undisturbed. Disturbed samples are those in which no effort is made to maintain the soil structure. Such samples may be secured for general observation and inspection, soil classification, moisture determination, or to obtain compaction characteristics. Relatively undisturbed samples vary from moderately disturbed split-barrel samples to almost completely undisturbed handcut samples. The importance of obtaining representative samples cannot be overemphasized. This requires considerable care because of the variations in natural deposits of earth materials. Representative samples are comparatively easy to secure in trenches, test pits, and cutbanks because the various undisturbed strata can be inspected visually. Bore holes, however, do not permit a visual inspection of the profile. It is also more difficult to secure representative samples by use of bore holes.

Samples may be either individual or composite. An individual sample is a single sample representing one stratum or type of soil. A group of individual samples, representing all the strata from a single test pit, may be combined in the same ratio as the thicknesses of the strata from which the samples were taken to form a composite sample. A sample may also be composited to any desired ratio of the soil types involved. It is usually preferable to obtain individual samples from each stratum of a soil deposit rather than to composite the sample in the field, since the most desirable depth and method of borrow excavation may be determined by trying several composite samples in the laboratory.

The sizes of samples required depend on the nature of the laboratory tests which may be required. The size of the samples will be determined by the laboratory doing the soil mechanics testing. Table 5-4 may be used as a guide.

Disturbed samples should be placed in bags or other suitable containers which will prevent loss of moisture and the fine fraction of the soil. Samples of silty and clayey soils proposed for borrow which are obtained for laboratory Atterberg limits test and Proctor compaction tests should be protected against drying and should be shipped in waterproof bags or other suitable containers to retain the natural moisture.

5. Special Consideration

Certain geologic conditions require special consideration beyond the minimum explorations. They are:

(a) subsidence — the potential for surface subsidence due to past or present solid, liquid (including ground water) or gaseous mineral extraction. In certain relatively dry fine-grained colluvial soils in southwestern North Dakota, sudden subsidence may take place upon saturation and loading. Suspected soils should be examined and brought to the attention of the designer;

(b) emergency spillways — relatively large dams with emergency spillways in soft rock or cemented soil materials that cannot be classified as soil nor as rock as generally defined for engineering purposes, and spillways in rock with defects require special and individual evaluation;

(c) mass movements — landslides and landslide potential at dam and reservoir sites, especially those in shales. Summarize the history of mass movement in the project area. Emergency spillway cuts and full reservoir effects must be given careful consideration;

(d) multi-purpose dams — the ground water and hydraulic characteristics of the entire reservoir area should be evaluated for leakage, and water budgets developed to determine if reservoir sealing is needed; and

(e) other — special studies and evaluations may be necessary where shales, dispersive soils, coal seams, and artesian water occur at a site. The economic and physical impacts of the pre-emption of mineral deposit, sand, gravel, coal, and oil by a reservoir should also be evaluated.
### Unified Soil Classification

#### Field Identification Procedures

<table>
<thead>
<tr>
<th>Group Symbol</th>
<th>Typical Names</th>
<th>Information Required for Describing Soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>GW</td>
<td>Well graded gravel, gravel-sand mixtures, little or no fines</td>
<td>Use typical name, indicate approximate percentages of sand and gravel, max. size, angularity, surface condition, and hardness of the coarse grains. Local or geologic name and other pertinent descriptive information, and symbol in parentheses.</td>
</tr>
<tr>
<td>CP</td>
<td>Poorly graded gravel, gravel-sand mixtures, little or no fines</td>
<td>For undisturbed soils add information on stratification, degree of cementation, consistency, moisture conditions, and drainage characteristics.</td>
</tr>
<tr>
<td>GM</td>
<td>Silty gravel, poorly graded gravel-sand mixtures.</td>
<td></td>
</tr>
<tr>
<td>GC</td>
<td>Clove gravel, poorly graded gravel-sand clay mixtures.</td>
<td></td>
</tr>
<tr>
<td>SW</td>
<td>Well graded sands, gravelly sands, little or no fines.</td>
<td></td>
</tr>
<tr>
<td>SP</td>
<td>Poorly graded sands, gravelly sands, little or no fines.</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>Silty sands, poorly graded sand-silt mixtures.</td>
<td></td>
</tr>
<tr>
<td>SC</td>
<td>Clove sand, poorly graded sand-silt mixtures.</td>
<td></td>
</tr>
</tbody>
</table>

#### Laboratory Classification Criteria

<table>
<thead>
<tr>
<th>Classification Criteria</th>
<th>C&lt;sub&gt;G&lt;/sub&gt;</th>
<th>C&lt;sub&gt;CL&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not meeting gradation requirements for GW</td>
<td>Greater than 4</td>
<td>0 to 50</td>
</tr>
<tr>
<td>Not meeting gradation requirements for CP</td>
<td>Between 4 and 1</td>
<td></td>
</tr>
<tr>
<td>Not meeting gradation requirements for GM</td>
<td>Greater than 5</td>
<td>Between 1 and 0</td>
</tr>
<tr>
<td>Not meeting gradation requirements for GC</td>
<td>Greater than 6</td>
<td>Between 0 and 0.5</td>
</tr>
<tr>
<td>Not meeting gradation requirements for SW</td>
<td>Greater than 6</td>
<td>Between 0 and 0.5</td>
</tr>
<tr>
<td>Not meeting gradation requirements for SP</td>
<td>Greater than 6</td>
<td>Between 0 and 0.5</td>
</tr>
<tr>
<td>Not meeting gradation requirements for SM</td>
<td>Greater than 6</td>
<td>Between 0 and 0.5</td>
</tr>
<tr>
<td>Not meeting gradation requirements for SC</td>
<td>Greater than 6</td>
<td>Between 0 and 0.5</td>
</tr>
</tbody>
</table>

#### Identification Procedures

<table>
<thead>
<tr>
<th>Group Symbol</th>
<th>Identification Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML</td>
<td>Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.</td>
</tr>
<tr>
<td>CL</td>
<td>Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.</td>
</tr>
<tr>
<td>DL</td>
<td>Organic silts and organic silt-clays of low plasticity.</td>
</tr>
<tr>
<td>ML</td>
<td>Inorganic silts, montmorillonitic fine sands or silty silts, plastic silts.</td>
</tr>
<tr>
<td>MH</td>
<td>Inorganic clays of high plasticity, very clays.</td>
</tr>
<tr>
<td>DM</td>
<td>Organic clays of medium to high plasticity.</td>
</tr>
</tbody>
</table>

#### Highly Organic Soils

<table>
<thead>
<tr>
<th>Group Symbol</th>
<th>Identification Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Peat and other highly organic soils.</td>
</tr>
</tbody>
</table>

---

1. Summary classifications. Stick consistency of lab groups are designated by combinations of group symbols. For example GW-GC, well graded gravel-sand mixture with clay binder.
2. All scale sizes on this chart are U.S. standard.

ANONIZED BY: SEWERAGE AND BUREAU OF RECLAMATION - JANUARY 1952
Table 5-4. Recommended Sizes of Samples

<table>
<thead>
<tr>
<th>Purpose of Material</th>
<th>Sample Size</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual and composite samples of disturbed earth materials for classification and proctor compaction tests.</td>
<td>Sufficient material, all passing the 3-inch sieve, to yield 75 pounds passing the No. 4 sieve.</td>
<td>Include information relative to the percentage by volume; 3 inches to 5 inches and plus 5 inches.</td>
</tr>
<tr>
<td>Soil-rock permeability tests.</td>
<td>300 pounds passing 3-inch sieve.</td>
<td>Air dried.</td>
</tr>
<tr>
<td>Relative density test.</td>
<td>150 pounds passing 3-inch sieve.</td>
<td>Air dried.</td>
</tr>
<tr>
<td>Moisture samples, inspection samples of soil, soil samples for sulfate determination.</td>
<td>Sealed pint or quart jars (full).</td>
<td>Individual inspection samples should represent range of moisture and type of materials.</td>
</tr>
<tr>
<td>Concrete aggregate.</td>
<td>600 pounds of pit-run sand if screened: 200 pounds of sand, 200 pounds of No. 4 to ¾-inch size, and 100 pounds of each of the other sizes produced, 400 pounds of quarry rock proposed for crushed aggregate.</td>
<td>For commercial sources, include data on plant-ownership, and service history of concrete made from aggregates.</td>
</tr>
<tr>
<td>Riprap.</td>
<td>200 pounds representative of quality or examine at site.</td>
<td>Method of excavation used, location of sources of supply and size range.</td>
</tr>
<tr>
<td>In-place density and water content of fine-grained soils above water table.</td>
<td>8 to 12-inch cubes or cylinders.</td>
<td>Sealed in suitable container.</td>
</tr>
</tbody>
</table>

E. Embankment and Foundation Design

The embankment and foundation design standards are dependent upon the complexity of the individual dam and the design classification of the dam. Generally, design class I and II dams have homogeneous embankments, are constructed without extensive moisture control, and do not have foundation and embankment drains. Design class III dams often require some type of embankment drain, and may require extensive design details. Design class IV and V dams, however, usually require foundation and embankment drains and close control of moisture and density of the fill materials. These dams generally have either a zoned or modified homogeneous embankment. The information in this section was developed to provide general design considerations for all dams along with specific recommendations for design class IV and V dams.

1. Selection of Embankment Type

Rolled earthfill dams are constructed in successive mechanically compacted layers. There are three types: diaphragm, homogeneous, and zoned. Figure 5-4 shows examples of these three types of earth embankment.

With the diaphragm type, the major portion of the embankment consists of a pervious material. A relatively thin diaphragm of impermeable material is provided to form the water barrier. The location of this diaphragm may vary from a blanket on the upstream face to a central vertical barrier. It may be constructed of earth, soil cement slurry, portland cement concrete, or other material. The blanket or core in an earthfill dam is considered to be a diaphragm if its horizontal thickness at any elevation is less than 10 feet. If the impervious earth zone equals or exceeds this thickness, the design is considered to be of the zoned embankment type. The construction of diaphragm-type earth embankments will be very limited in North Dakota. They should only be
used where the supply of impervious soil is so limited as to preclude the construction of the homogeneous or zoned embankment type of dam.

The homogeneous type of embankment is composed of a single type of material. The material comprising the dam must be sufficiently impervious to provide an adequate water barrier, and the slopes must be relatively flat for stability. The downstream slope of a homogeneous dam may eventually be affected by seepage to a height of roughly one-third the depth of the reservoir pool.

A common type of rolled earthfill dam has a central impervious core, and is flanked by zones of material considerably more pervious. The pervious zones enclose, support, and protect the impervious core; the upstream pervious zone affords stability against rapid drawdown; and the downstream pervious zone acts as a drain to control the line of seepage. For most effective control of seepage, the pervious sections should have, if possible, a progressive increase in permeability from the center to the outer slopes.

The type of rolled-fill dam section selected will primarily be determined by the materials found on the site. Where impervious material is in extremely short supply, a diaphragm type of section may be the only practical alternative. Where the only soil material on the site is impervious, the situation may dictate a homogeneous or modified homogeneous section. Where the materials on the site contain both pervious and impervious materials, the zoned section will probably be preferable because it generally allows steeper embankment slopes.

The designer will have to consider the type of materials which will be excavated from the cutoff trench and the emergency spillway, how these materials can best be used in the embankment design, and what configuration of materials used will result in the most economical section.

2. Foundation Cutoffs

Many of the rolled-earth dam sites contain foundations consisting of alluvial deposits of pervious sand and gravel or shale chips at or near the surface with an impervious stratum of rock, clay, or shale at a greater depth. A positive cutoff is recommended where the impervious stratum joins the foundation with the base of the impervious portion of the embankment. A positive cutoff is desirable, particularly where the water in storage is used for irrigation, municipal or industrial water supply.

Where a positive cutoff is impractical because of the depth to an impervious stratum, a partial cutoff may provide foundation stability and reduce seepage losses to acceptable levels. Regardless of the foundation conditions, the only way to determine the economical feasibility of a positive cutoff or various percentages of partial cutoff is to make a seepage analysis and water balance.

3. Height

The design height of an earth embankment should be sufficient to prevent overtopping during passage of either the freeboard hydrograph (see Table 5-1, page 5), or the velocity hydrograph, plus the freeboard required for wave action, whichever is larger. The design height of the dam should be increased by the amount needed to compensate for settlement. Therefore, the suggested dam height is equal to the greater of the following: (1) the elevation at the normal water level, plus the increase in water level resulting from a freeboard hydrograph event, plus an allowance for settlement; or (2) the elevation at the normal water level, plus the increase in water level resulting from velocity hydrograph event, plus an allowance for wave action, plus an allowance for settlement. The height of reservoir waves as a function of the length of the fetch and the velocity of the wind. Figure 5-5 shows the reservoir wave height based on fetch and an 80 mile per hour wind velocity. The following formula can be used to determine the wave height for other wind velocities:

\[ H_w = 2.5 + 0.17 \sqrt{V_F} - \frac{1}{\sqrt{F}} \]

where:
- \( H_w \) = height of the wave in feet
- \( V \) = wind velocity in miles per hour
- \( F \) = length of the fetch in miles

![Figure 5-5. Reservoir Wave Height](image)

4. Top Width

The recommended minimum top width of the embankment is shown in Table 5-5.

The width may be greater than those shown above in order to accommodate embankment zoning, provide

<table>
<thead>
<tr>
<th>Dam Height (H) (Feet)</th>
<th>Top Width (Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 or less</td>
<td>8</td>
</tr>
<tr>
<td>15 - 19</td>
<td>10</td>
</tr>
<tr>
<td>20 - 24</td>
<td>12</td>
</tr>
<tr>
<td>25 - 34</td>
<td>14</td>
</tr>
<tr>
<td>35 - 95</td>
<td>( (H + 35)/5 )</td>
</tr>
<tr>
<td>Over 95</td>
<td>26</td>
</tr>
</tbody>
</table>
roadway access and traffic safety and/or provide structural stability.

When the embankment top is used as a public roadway, the minimum width should be 16 feet for one-way and 26 feet for two-way traffic. Guard rails or other safety measures may be required and should meet the requirements of the state and county highway departments.

5. Berming

There are several reasons for the installation of berms on rolled-fill embankments. Berms may be needed to provide stability to the structure, particularly where the foundation is soft and weak. In this case, the berm or berms may be of considerable width.

Berms may be placed on either the upstream, downstream, or both faces of a dam to provide access to trash racks and instrumentation. Normally, the upstream face of the dam will have protection against destructive wave action and will require no additional protection against water draining off the embankment. However, the downstream face for dams over about 30 feet in height probably will require drainage berms to dispose of the embankment drainage without eroding the downstream face of the embankment. Downstream drainage berms can be thought of as terraces. They are designed to break up the length of the slope and should be analyzed as a terrace. The greater the length of the embankment, the closer the berms should be spaced and, conversely, the shorter the embankment, the further the berms may be spaced apart.

Surface drainage on the abutments and valley floor is easily overlooked in the design of earth dams. This may result in gullying at the contact of the embankment with earth abutments from which vegetation has been removed during the construction operations. This can be controlled by sod chutes, by a pipe outlet or by constructing a gutter along the contact consisting of coarse aggregate or small stones. An analysis should be made to make sure the expected velocities do not move the aggregate used to construct the gutter. Filter cloth should be installed under the rock material.

6. Foundation and Embankment Drainage

The impervious portion of an earthfill dam provides resistance to seepage which creates a reservoir. Soil varies in permeability, but even the tightest clays are porous and cannot prevent all seepage. Therefore, seepage control is a major concern in dam design. The filter and drainage system must have adequate permeability but still control piping through the embankment.

The percolation of reservoir water through the impervious section depends on the fluctuations of the reservoir level, the degree of permeability of the impervious material in the horizontal and vertical directions, the amount of remaining pore-water pressures caused by compressive forces during construction, and the element of time. The upper surface of seepage is called the phreatic surface; in a cross section it is referred to as a phreatic line. Although the soil may be saturated by capillarity above this line, giving rise to a "line of saturation," seepage is limited to the portion below the phreatic line.

Several terms will be used in this section:

Interceptor Drain — a drain that physically intercepts flow paths or fully penetrates water bearing strata.

Pressure Relief Drain — a drain that produces an area of low pressure to which water will flow from adjacent areas of higher pressure.

Filter Material — filter cloth or a layer or combination of layers of pervious materials designed and installed in such a manner as to provide for water movement, yet control movement of solid particles due to flowing water.

Drain Material — sand, gravel or rock that has specific gradation limits designed for required permeability and internal stability.

Base Material — any material (embankment, backfill, foundation, or other filter layer) through which water moves into a drainage system.

Coefficient of Permeability — the rate of discharge of water under laminar flow conditions through a unit cross-sectional area of a porous medium under a unity hydraulic gradient.

Drains are included in embankments and foundations for two basic reasons:

(a) to prevent piping by controlling migration of soil particles under seepage flow; and

(b) to control pressure build-up by providing adequate capacity to carry the seepage flow.

There are no hard and fast rules for selecting a reasonable margin of safety for drain design. Judgment in this respect must be related to: (1) past experience with similar materials, (2) the detail used in site investigations and testing programs, and (3) the limitations of analyses in representing site conditions.

Where extensive drainage is required, the drainage cost can be a substantial part of the construction cost. For this reason, the designer should be aware of the availability of pervious materials on or near the construction site. Designing the drain to utilize local materials can result in substantial savings, even when processing is required.

Four types of drains and the site conditions are discussed below:

Chimney drains are primarily interceptors that provide positive control of embankment seepage. In this case, water that percolates through the soil is intercepted to ensure that seepage does not occur in materials downstream from the drain.

Chimney drains are applicable where the downstream embankment material cannot be allowed to saturate. The variability of soils in many borrow sources is so great that the engineering properties of the resulting fill cannot be determined with any reasonable degree of accuracy. It may be more economical to place these materials in a "random fill" zone downstream from a positive drain than to waste or disregard them. Materials suspect of undergoing marked and unpredictable changes upon saturation should be placed where they cannot become saturated. Soils containing concentrations of soluble salts and degradable shale derivatives are examples. Middle Branch Park River Detention Dam 10, designed by the Soil Conservation Service, utilizes a chimney drain (Figure 5-6).
Figure 5-6. Chimney and Foundation Drain System
(Middle Branch Park River Watershed Dam, #10-SCS)

PLAN VIEW CHIMNEY DRAIN AND FOUNDATION DRAIN

SECTION A-A. PROFILE OF CHIMNEY DRAIN

Chimney drains are also applicable where embankment materials are susceptible to cracking. In this case, water which comes primarily through cracks within the embankment is intercepted to prevent piping and to ensure the overall safety of the dam.

Another type of internal drain is the horizontal blanket drain. The horizontal blanket drain is primarily a pressure relief drain placed in the downstream area of an embankment. Horizontal blanket drains are applicable when: (1) there is no significant difference between the vertical and horizontal permeability of the embankment or the foundation; (2) when bedrock is pervious (drain placed directly on bedrock); or (3) when a good bond cannot be obtained between impervious bedrock and the embankment. Figure 5-7 shows a horizontal blanket drain.

Another type of drain is the foundation drain. The foundation drain is primarily a pressure relief drain. It is most effective when it penetrates all pervious strata. Foundation drains are applicable when the horizontal permeability of the foundation is significantly greater than the vertical permeability. It is often used to relieve pressure from foundation aquifers or to control pipeable foundation materials. Dead Colt Creek Dam near Lisbon, North Dakota utilizes a foundation drain (Figure 5-8).

The final type of drain is pressure relief wells. These wells are generally located near the downstream toe of an embankment for accessibility. Relief wells are particularly adapted for control of pressures from confined and alluvial aquifers that are too deep to drain with foundation drains. Pressure relief wells are often used

Figure 5-7. Filter Blanket and Toe Drain System

WATER SURFACE

GRANULE

FINE FILTER MATERIAL
in conjunction with the foundation drain as shown in Figure 5-9.

Drain outlets are needed to conduct the accumulated seepage from the embankment or foundation drain to a controlled discharge point. It is recommended that separate outlets be provided for foundation, abutment, embankment and structure drains for ease of monitoring.

There are several special situations which do not conveniently fit any of the four types of drains discussed above. These are:

(a) Embankment Zones — When an embankment zone is to function as a drain, material placed in that zone must meet the permeability and piping requirements for drain material. On-site materials generally contain enough fines to limit permeability. Permeability determinations and flow nets will provide guidance on the effectiveness of these materials for drainage zones.

(b) Springs — It may be necessary to increase the capacity of drains to accommodate flow from springs. In many cases, it is desirable to provide separate drainage outlets for springs.

(c) External Abutment Drains — Drains outside the limits of an embankment should be designed by the procedures used for drains placed under embankments.

(d) Abutment Well Drains — These are either horizontal or slanted wells for drainage of deeply fractured rock abutments and other deep, pervious abutment materials. Design procedures are beyond the scope of this handbook. For detailed information on site investigation requirements and design procedures and considerations, consult soil mechanics textbooks or specialized manuals, and soil mechanics notes issued by the Bureau of Reclamation, Corps of Engineers, or Soil Conservation Service.

Two recent, excellent discussions on this subject are part of the Journal of Geotechnical Engineering, Vol. 110, No. 6, June, 1984. These papers, authored by Sherard, Dunnigan, and Talbot, are entitled: "Basic Properties of Sand and Gravel Filters" and "Filters for Silts and Clays."

7. Structural Stability
Potential failure from sliding, sloughing or rotation should be analyzed and documented. Embankment and foundation design and geotechnical exploration should be consistent with the complexity of the site and the potential for failure. Anticipated settlement, seepage, and cracking should also be considered and documented.

A seismic coefficient of 0.05 should be used for the entire state of North Dakota in a slope stability analysis. The seismic coefficient is the fraction of a weight to be used as a horizontal force in a quasi-static analysis.

At the present time, various procedures are available for calculating the factors of safety of embankment sections. Generally, the basic methods include either the circular arc or the sliding wedge method or both. However, in lieu of the circular arc, the logarithmic spiral method and the sliding wedge method may be modified by use of various arcs, lines of radii of curvature, or composite curves.

The slope stability criteria used in this manual is that used by the SCS. Other agencies or textbooks have excellent discussions and criteria for slope stability, although they often use different nomenclature. The nomenclature used by the SCS for the various slope tests and that commonly used by the geotechnical profession are shown in Table 5-6.

Analyses are to be made for the conditions that are most critical during the design life of the structure. Conditions analyzed are based on various water and loading conditions of the embankment and foundation. The following conditions should be considered: (1) end of construction; (2) steady seepage; (3) rapid drawdown; and (4) seismic. For each case, the analysis should be based on the shear strengths shown in Table 5-7. Minimum safety factors for each condition are also shown in the table. The factor of safety calculations should be based on the ratio of the shear strength available to the shear strength mobilized.
Table 5-6. Nomenclature of Shear Strength Tests

<table>
<thead>
<tr>
<th>Test Condition</th>
<th>Common Literature Description</th>
<th>Reference for Suggested Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unconsolidated, Undrained</td>
<td>UU or Q</td>
<td>ASTM D2850</td>
</tr>
<tr>
<td>Consolidated, Undrained</td>
<td>CU or R</td>
<td>1</td>
</tr>
<tr>
<td>Consolidated, Undrained with</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Pore Pressures Measured</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consolidated, Drained</td>
<td>CD² or S</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

3  If the CD tests are run slow enough, the shear strength parameters obtained may be used in lieu of CU parameters.

8. Protection of Embankment Surface

It is generally necessary to provide some protection to the upstream face of a dam. Design class I and II dams seldom need more than vegetative protection on the upstream face. The orientation and length of the permanent pool, the purpose of the reservoir, and the duration of stages in flood control pools all affect the need for and the type of embankment protection.

Protection for design class III, IV and V dams may consist of rock riprap, either dumped or hand-placed, soil cement, scoria or combinations of the above. Scoria is generally not used if rock is available as it breaks down easily through weathering and requires considerable maintenance. Rock riprap should consist of hard durable rock, well graded, placed at a minimum thickness of 18 inches on 6 inches of well-graded gravel or a layer of engineering fabric (filter cloth).

Judgment is required in the design of the vertical height of the riprap. The ultimate in protection would be to riprap the face of the dam from the toe to the crest, which has been done on some large Corps projects in North Dakota. This is expensive and may not be justified on smaller dams. An alternative for protection above the principal spillway would be to riprap the portion of the embankment that would be underwater for a 48-hour period during the principal spillway design event (Table 5-1, page 5), plus an allowance for wave height (Figure 5-5, page 13). Steep embankment slopes and erodible soils may require additional protection.

The protection below the normal pool elevation is dependent upon several factors including the purpose of the reservoir and the base flow of the inflow stream. A water supply reservoir will generally have a wide range of stages during the year due to withdrawals. A recreation dam on a stream with a base flow may only require riprap from three feet below the permanent reservoir elevation. The same type of reservoir on a stream with little base flow may require that the riprap extend six or more feet below the permanent elevation. Recreation reservoirs are subject to wave action from boats and water-skiers and, therefore, it is necessary to provide adequate riprap above and below the normal reservoir water level.

Recommended references on slope protection include the Soil Conservation Service Technical Release No. 56, “A Guide for Design and/or Layout of Vegetative Wave Protection for Earth Dam Embankments,” and No. 69, “Riprap for Slope Protection Against Wave Action.”

9. Instrumentation

Instrumentation can significantly improve the overall safety of a dam by providing continuous surveillance of the structure. Instrumentation is normally associated with large high hazard dams, but it is also used in dams with unusual design features. The State Engineer recommends that instrumentation be incorporated into all class V dams and that it be considered for all class IV dams.

Instrumentation refers to the method and equipment used to make physical measurements of dams. Instrumentations is not, however, a substitute for inspection, but is a supplement to visual observations and inspections. Visual examinations are aided by monitoring instruments that measure seepage and leakage through and around the embankment, movements of the embankment and foundation, and water levels and pressures within the embankment and the foundation. Adequate records of such measurement devices, along with the visual observations, should be maintained. To be effective, these records should be continuous and periodically reviewed by a professional engineer versed in the design and vulnerability of embankment structures. These reviewers should be able to distinguish the important indicators from the unimportant. A tendency toward change in behavior of the dam should signal a need for further review and analyses.

Measurements and readings should be taken frequently during construction and after completion of the project. The number of measurements may be reduced if the structure performs satisfactorily. If the structure shows any tendency toward weakness or unsatisfactory performance, the time interval between measurements should be shortened appropriately to provide analytic data that can warn of impending problems. Post-construction monitoring should continue for several cycles of reservoir operation to document cyclic changes.

There are three general types of instruments used to monitor dams. These include seepage monitoring instruments, embankment movement instruments and water pressure instruments (piezometers). Table 5-8 provides additional information on various monitoring instruments.

a) Seepage and Leakage

All dams will leak to varying degrees, but every leak should be monitored and recorded. If there is a flow, the quantity flowing should be measured by creating a drop and installing a pipe, a v-notched weir, a weir, or a flume. A record should be kept of the discharge and the reservoir elevation. Toe and/or foundation drains should
<table>
<thead>
<tr>
<th>Design Condition</th>
<th>Primary Assumption</th>
<th>Remarks</th>
<th>Shear Strength To Be Used 1/2</th>
<th>Minimum Factor of Safety (Dam Design Class)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. End of construction</td>
<td>Significant construction pore pressures expected</td>
<td>1. Embankment containing im-pervious soils at water contents equal to or greater than the optimum water content and/or 2. Saturated impervious foundation strata too thick to consolidate during construction For soil zones where significant construction pore pressure is not expected</td>
<td>UU</td>
<td>1.4 (all classes) (1.3 is acceptable for embankments on strong foundations, i.e., the failure surface is located entirely in the embankment)</td>
</tr>
<tr>
<td>II. Rapid drawdown</td>
<td>Drawdown from the emergency spillway crest to the crest of the lowest gated or ungated outlet</td>
<td>Failure surface can be confined to the embankment or extend into the foundation if low permeability soils are involved Use alternative 1 or 2 below 1. Lowest shear strength from composite envelope of CU and C0, or 2. Most limiting of C03/ and CU</td>
<td></td>
<td>1.2 (all classes)</td>
</tr>
<tr>
<td>III. Steady seepage without seismic forces</td>
<td>1. Water surface at the principal spillway 2. Phreatic surface fully developed through the embankment 3. Piezometric surface for estimating uplift in saturated soil zones is determined with reservoir at the emergency spillway crest</td>
<td>Failure plane confined to the embankment only Failure plane extends into the foundation</td>
<td>CU or CD</td>
<td>1.5 (class IV, V) 1.4 (class III)</td>
</tr>
<tr>
<td>IV. Steady seepage with seismic forces</td>
<td>1. Water surface at the crest of the principal spillway 2. Phreatic surface fully developed through the embankment</td>
<td>Failure plane may be confined to the embankment or may extend into the foundation</td>
<td>Most limiting3/ of four combinations as follows: Comb. Found Emb. No. Soil Soil</td>
<td>1.0 (all classes)</td>
</tr>
</tbody>
</table>

1/ Always use CU or CD shear strength for pervious soil zones within the foundation or embankment.

2/ Use infinite slope stability analysis whenever the C or C intercept strength is zero for free draining soils that are tested to simulate low confining pressures. This situation exists for failure planes located near the embankment surface.

3/ Most limiting is the combination resulting the lowest factor of safety. Some combinations may be eliminated by inspection and judgement. Additional combinations may be necessary for some stratified foundations.
### Table 5-8. Monitoring Instruments

<table>
<thead>
<tr>
<th>Type</th>
<th>Purpose and Use</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Piezometers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) observation wells</td>
<td>measures water height in a free stand pipe or vertical tube as a result of water pressure at the openings in the stand pipe.</td>
<td>a, b, c, e, j, and k</td>
</tr>
<tr>
<td>(hydraulic piezometer)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) electronic piezometer</td>
<td>measures pore water pressure by deflecting a calibrated membrane and the deflection is measured electronically to give water pressure. It provides a check on seepage conditions and performance of the drainage system.</td>
<td>a, c, d, g, h, i, and j</td>
</tr>
<tr>
<td>c) gas pressure piezometer</td>
<td>measures pore water pressure by balancing it with pressurized gas in a calibrating unit. It also provides a check on seepage conditions and performance of the drainage system.</td>
<td>a, c, d, g, h, i, j, and l</td>
</tr>
<tr>
<td>2. Inclinometers</td>
<td>it is a vertical tube placed in the embankment after construction, and used to monitor internal displacements or movements within the embankment or foundation of usually higher dams. These movements will undoubtedly be detected before the effects appear on the surface. The system uses special casting with grooves on the inside at the quarter points.</td>
<td>c, f, and j</td>
</tr>
<tr>
<td>3. Triangulation and</td>
<td>iron pins and concrete monuments usually installed along an upper edge of the embankment and/or along a downstream slope._survey instruments are used to note location and elevations. Sometimes a base line can be set up and also points on the downstream slope of a dam. These distances can be checked then with an ESM.</td>
<td></td>
</tr>
<tr>
<td>triilateration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Tiltmeters</td>
<td>use to measure internal deformation rotational and tilting.</td>
<td>b, c, i, and j</td>
</tr>
<tr>
<td>5. Earth pressure cells</td>
<td>measures earth pressures at contact plane between soil and structure.</td>
<td>c, d, and j</td>
</tr>
</tbody>
</table>

**REMARKS**

- a) can be used to determine phreatic line when a set of wells runs perpendicular to centerline.
- b) can be installed after dam is completed.
- c) the reservoir elevation should also be recorded.
- d) usually installed during construction.
- e) should be capped when not being read.
- f) relatively expensive to install and monitor.
- g) can be installed in the original foundation.
- h) has a better response to small pressure changes than an observation well.
- i) an engineer should be consulted to evaluate the soils and supervise the installation of piezometers.
- j) each instrument reading should be plotted, graphed and compared to previous readings.
- k) observation wells may be read in the following ways:
  - (1) measuring tape with weight — record depth and length wetted from known top of case elevation;
  - (2) placing air pipe and gage into well. Pressure indicates depth of water above lower end of pipe;
  - (3) a graduated electric cord and current meter;
  - (4) sonic sounder and recorder;
  - (5) pressure transducer and float and recording drum.
- l) gas appears to be more trouble-free than the electronic.

also be monitored and recorded along with the reservoir elevation. Any wet spots should be noted and the location, size and condition recorded.

**b) Embankment Movements**

Considerable movement of embankment dams can be anticipated during and immediately after construction. Much of the movement may be attributed to foundation settlement under the loading of the embankment. The embankment will also move as the reservoir is filled for the first time and may periodically cycle movements as the reservoir is emptied and filled in succeeding seasons. Movements are determined by periodic measurements of monuments placed in or on the structure and abutments. For existing dams, monumentation to measure movements is usually limited to the crest and downstream slopes. The monuments usually consist of steel rods or surveyor’s markers imbedded in concrete placed in excavations on the embankment of the abutments. Differences in elevation and location of the monuments are measured by transit and level surveys of the monuments.

Measurements of the locations of the monuments on the surface of the embankment should be such that changes in both vertical and horizontal locations are measured. The measurements should be reduced to graphical displays of changes in vertical location, changes in horizontal location along the axis of the embankment, and changes in horizontal location transverse to the axis of the embankment (upstream and downstream). The water surface elevation in the reservoir at the time of measurement of the monument is important and should be recorded along with the
monument location data. Whenever possible the monuments should be tied to a bench mark that is outside the influence of the dam and reservoir. Monuments should be located such that they are not damaged by normal traffic or operations.

c) Piezometric Pressures

A primary indicator of the performance of an embankment is the water pressure distribution within the structure and its foundation. Water pressures in the embankments are measured by piezometers. There are basically three types of piezometers in common usage: (1) a hydraulic piezometer in which the water pressure is obtained directly by measuring the elevation of water standing in a pipe or vertical tube; (2) an electronic piezometer in which the water pressure deflects a calibrated membrane and the deflection is measured electronically to give the water pressure; and (3) a gas pressure unit in which the water pressure is measured by balancing it with a pressurized gas in a calibrated unit.

Piezometers should be installed in an embankment structure so that the location of the free water surface or phreatic line can be determined. The line of piezometers would be perpendicular to the longitudinal axis of the embankment. In large structures there may be several lines of piezometers, while in smaller structures and existing dams perhaps one line would be adequate.

F. Principal Spillway Design

1. General

The design standards and criteria for the principal spillway are primarily dependent on the dam design classification and purpose. Design classification I and II dams may not require a principal spillway, only a grassed emergency spillway. The requirement for a principal spillway on a small dam is more dependent on the drainage area and on the presence of base flow. If a class I or II dam does not need a principal spillway, it is advisable to include a small pipe to protect the vegetation in the emergency spillway from long duration flows. This pipe should be large enough to pass the normal summer flows.

It is suggested that the class III, IV, and V dams be designed in accordance with the hydrologic criteria shown in Table 5-1, page 5. In addition to these criteria, the following must be considered in determining the design capacity: (1) the purpose of the dam; (2) the amount of storage provided by the retarding pool; (3) the kind of emergency spillway; (4) the stream channel capacity and stability downstream; (5) the potential damage from prolonged storage in the retarding pool; (6) the potential damage from prolonged high outflow rates; (7) the possibility of substantial runoff from two or more storms before the retarding pool has emptied; (8) the limitations imposed by water rights or other legal requirements; (9) the environmental concerns; (10) the planned or potential alterations of the channel downstream; (11) the planned or potential development of the downstream floodplain; and (12) the necessity to pass base and flood flows during construction.

In addition to the principal and emergency spillways, downstream water rights may require a low level riparian outlet or an alternative method of water release. The required discharge capacity and frequency of use will normally determine the type of riparian release.

Corrugated metal pipes (CMP) are not recommended for design classification IV and V dams. When used in smaller dams, the CMP should be coated for longer life. The use of corrugated metal is more advisable for use in dry dams than dams with permanent storage. Design classification IV and V dams normally require concrete principal spillways — monolithic concrete box, concrete pipe, steel cylinder concrete pipe or a concrete chute.

The quality and type of concrete used in dams is also dependent on the design classification. Generally, 3,000 psi concrete is adequate for classes I, II and III dams. Air entrained 4,000 psi concrete is suggested for design class IV and V dams.

2. Types of Principal Spillways

There are two general types of principal spillways commonly used in North Dakota — a conduit (pipe or box culvert) and a chute spillway. Heart Butte Dam near Elgin, North Dakota, utilizes a conduit type main spillway (See Figure 5-10). Figure 5-11 shows the chute spillway system for Epping Dam in North Dakota.

a. Conduit Principal Spillway

Conduit spillways consist of an inlet structure, a closed discharge pipe or box culvert and an outlet structure or plunge pool. A conduit spillway can be used advantageously on most dams in North Dakota. One advantage of this type of spillway is that near maximum capacity is attained at relatively low heads. This characteristic makes the spillway ideal for use where the maximum spillway outflow is to be limited. However, there is little increase in capacity at higher reservoir levels.

The inlet structure should be designed to maintain the reservoir pool level near the inlet crest elevation during low flood periods; to establish full pipe flow at as low a head as practical; and to operate without excessive surging, vibration, or vortex action. This requires the inlet to have a larger cross-sectional area than the main conduit.

Inlet structures should be designed to exclude trash too large to pass freely through the spillway and the outlet structure. Trash racks should be designed to provide positive protection against clogging of the spillway under any operating level. The average velocity of flow through a clean trash rack should not exceed 2.5 feet per second under the full range of stage and discharge. Velocity should be computed on the basis of the net area of opening through the rack.

If the inlet structure is used to keep the sediment pool drained, the trash rack or riser should extend above the anticipated sediment elevation. The velocity through the net area of the trash rack should not exceed two feet per second when the water surface is five feet above the top of the trash rack or riser inlet.

For small design class I and II dams and for dry dams, the inlet structure may consist of only a flared section or a hooded-inlet to improve the hydraulic efficiency of the conduit entrance. An inlet weir box is commonly
used with a hooded-inlet to produce full conduit flow at a lower head.

On larger structures, however, a drop-inlet is often required to decrease the horizontal slope of the main conduit. The main conduit should have an adequate slope to ensure free drainage of all sections of the conduit including camber, but the maximum slope should not exceed five percent. The drop-inlet structure should be designed to structurally withstand all water, earth, ice, and earthquake loads to which they may be subjected. Figure 5-12 shows the drop-inlet structure for Dead Colt Creek Dam located near Lisbon, North Dakota.

Standard drop-inlet structures have been developed by the Soil Conservation Service. These have an inside width equal to the diameter of the conduit and an inside length equal to three times the diameter of the conduit. All closed conduit spillways designed for pressure flow require adequate anti-vortex devices.

The conduit should be straight in alignment when viewed in plan. Changes from straight alignment should be accomplished by watertight angle changes at joints or by special elbows having a radius equal to or greater than the diameter of the conduit. Thrust blocks are to be provided if special pipe elbows are used. Thrust blocks distribute the thrust caused by change in direction, providing for the maximum possible discharge.

Discharge characteristics of the drop-inlet spillway may vary with the range of the head. The control will shift according to the relative discharge capacities of the weir, the transition, and the conduit. Therefore, hydraulic model testing should be considered if the maximum total head on the spillway is more than 40 feet or if the conduit velocity exceeds 40 feet per second.

Conduits under earth embankments must support the external loads with an adequate factor of safety. They must withstand the internal hydraulic pressure without leakage under full external load and settlement and convey water at the design velocity without damage to the interior surface of the conduit. Rigid principal spillway conduits should be designed as positive projecting conduits.
Figure 5-12. Conduit Spillway with Anti-Seep Collar and Concrete Cradle
(Dead Colt Creek Dam: Lisbon, ND)

EMBANKMENT ELEVATION VIEW
(not to scale)

DETAIL A
CONDUIT FILTER DRAIN
(not to scale)

DETAIL B
ANTI-SEEP COLLAR
AND CONCRETE CRADLE
(not to scale)

DETAIL C
PIPE AND CRADLE JOINT
(side view)
(not to scale)
The material used for the conduit should be determined by the size of the dam, the economic life of the dam, and the relative ease of replacement. Class IV and V dams should utilize precast reinforced concrete pipe or cast-in-place rectangular reinforced concrete box culverts.

Concrete cradles are recommended under all concrete pipes. It is important to articulate the cradle at all joints. Figure 5-12 shows the concrete cradle design for the Dead Colt Creek Dam near Lisbon, North Dakota.

If corrugated metal pipes are used in larger dams, the joints should be electrically bridged on the outside of the pipe with insulated copper wire, No. 6 AWG or larger, securely attached to the uncoated pipe metal at both sides of the joint. The wire should have a tough waterproof insulation designed for direct burial, with a rating of at least 600 volts. Bare wire and exposed pipe metal at the point of connection should be thoroughly coated with a coating equivalent to the original pipe coating, to prevent the entry of moisture.

Geophysical exploration utilizing electrical resistivity and pH (soil acidity) of the subgrade and backfill materials to be adjacent to the conduit should be made. Resistivity measurements should be made on saturated samples. Cathodic protection should be provided for corrugated steel pipe in soil whose resistivity in a saturated condition is less than 4000 ohms cm or whose pH is lower than five.

Conduits should be designed and constructed to remain watertight under maximum anticipated hydrostatic head and maximum probable joint opening, including the effects of joint rotation and the required margin of safety. The required joint extensibility in concrete pipes is equal to the unit horizontal strain in the earth adjacent to the conduit, multiplied by the length (in inches) of the section of conduits between joints, plus the extension (in inches) due to calculated joint rotation, plus a margin of safety. A margin of safety of not less than 0.5 inch should be used.

The required joint extensibility, plus the maximum permissible joint gap, equals the required joint length. The required joint extensibility depends on the maximum potential foundation consolidation under the spillway barrel. For Class IV and V dams, the consolidation should be estimated from adequate foundation borings and samples, soil mechanics laboratory tests, and engineering analysis. For Class II dams, where undisturbed foundation samples are not taken for other purposes, approximate procedures based on soil classification and experience may be used for estimating foundation consolidation.

Only joints incorporating a round rubber gasket set in a positive groove should be used on precast concrete pipe conduits. Concrete pipe should have steel joint rings providing rubber to steel contact in the joint.

Articulation of the conduit (freedom for required rotation) should be provided at each joint in the conduit, at the junction of the conduit with the riser and at any outlet structure.

Piping and seepage control around the conduit is an important consideration. For many years, anti-seep collars were required on conduits passing through earth embankment dams. Although no longer used in all dams, anti-seep collars are still an acceptable method for seepage control. When used, the anti-seep collars should be designed such to extend the seepage path by 15 percent through the saturated zone. The major disadvantage of anti-seep collars is that it is difficult to compact earth directly against the concrete structure. A large amount of compaction by hand labor is needed. An alternative to anti-seep collars is a filter drain around a section of the conduit. However, conduit filter drains still require manual compaction around the conduit.

The Dead Colt Creek Dam utilizes both anti-seep collars and a conduit filter drain. Figure 5-12 also shows the embankment and principal spillway of the project including details of the anti-seep collars and the conduit filter drain.

Foundation drains and embankment chimney drains that meet the minimum size and location limits are sufficient without a separate filter drain. The use of anti-seep collars is recommended if a drainage system is not utilized in the structure.

When spillway flows drop from the reservoir pool level to the downstream outlet channel level, the static head is converted to kinetic energy. This energy manifests itself in the form of high velocities which, if not impeded, results in erosion. Means of returning the flow to the river without serious scour or erosion to the toe of the dam or damage to adjacent structures must be provided.

The choice of the type of outlet structure should be based on a careful consideration of all site and flow conditions that may affect operation and energy dissipation. The following guidelines should be considered in selecting the type of outlet structure:

- Cantilever outlet and plunge pools may be installed where their use does not create a piping hazard in the foundation, and where they are compatible with other conditions. Plunge pools are to be designed to dissipate the energy and to be stable. Unless the pool is to be in bedrock or very erosion resistant materials, riprap will be necessary to ensure stability.

- Cantilever outlets should be supported on bents or piers and are to extend a minimum of eight feet beyond the bents or piers. The bents are to be located downstream from the intersection of the downstream slope of the earth embankment, with the grade line of the channel below the dam. They should extend below the lowest elevation anticipated in the plunge pool. The invert of the cantilever outlet should be at least one foot above the tailwater elevation at maximum discharge.

- Saint Anthony Falls (SAF) basins may be used where they are economical and where there is adequate control of tailwater. Care must be taken to ensure that the outlet channel is properly designed and is constructed in accordance with the design. Riprap may be required to ensure that the design tailwater is maintained.

- Impact basins may be used when positive measures are taken to prevent large debris from entering the conduit.

b. Chute Spillway

Chute spillways ordinarily consist of an entrance
channel, a control structure and an outlet channel. The U.S. Bureau of Reclamation’s “Design of Small Dams” is an excellent reference.

Favorable factors influencing the selection of chute spillways are: the simplicity of their design and construction, their adaptability to almost any foundation condition, the overall economy obtained by using the spillway excavation in the embankment, and the high discharge-head ratio possible. The disadvantages to chute spillways stem primarily from settlement and uplift problems which may require structure drainage. Chute spillways provide only very limited flood control advantages.

G. Emergency (Secondary) Spillway Design

1. Location

Emergency spillways, whenever possible, should be located away from the dam in an undisturbed area. Topographic saddles generally make good sites. The layout and profile of vegetated or earth spillways should provide a maximum bulk of material to ensure safety against breaching of the spillway during the passage of the freeboard hydrograph.

2. Design Considerations

Excavated spillways consist of three elements: the inlet channel (sometimes referred to as the forebay), the control section, and the exit channel.

The relationship between the water surface elevation in the reservoir and the discharge through the emergency spillway should be evaluated by computing the head losses in the inlet channel upstream of the control section. If a control section is not used, the spillway should be evaluated by computing the water surface profile through the full length of the spillway. Bernoulli’s equation and Manning’s formula should be used to evaluate friction losses, compute water surface profiles and determine velocities. Subcritical flow exists in the inlet channel. The flow conditions change to critical in the control section.

It is recommended that the inlet channel be level for a minimum distance of 30 feet upstream from the control section. This level part of the inlet channel should be the same width as the exit channel, and its centerline should be straight and coincide with the centerline of the exit channel. A curved centerline is permissible in the inlet channel upstream from the level section, but it must be tangent to the centerline of the level section.

The centerline of the exit channel must be straight and perpendicular to the control section for a distance equal to at least one-half of the maximum base width of the dam. Curvature may be introduced below this point, provided that the flowing water will not impede on the dam should the channel fail at the curve.

The exit channel should be as long as is reasonably practical. It should be of sufficient slope to ensure supercritical flow for all discharges greater than 25 percent of the freeboard hydrograph flows. It is also recommended that the ground-water level be determined in the emergency spillway area. If the ground-water table is at or near the surface, or if the emergency spillway outlet channel intercepts the water table, a drainage system may be necessary.

The maximum velocity limitations for vegetated channels apply to the exit channel (See Table 5-2, page 6). They should not be exceeded in the reach, where an exit channel failure might cause the flow to impinge on the toe of the dam. The velocity limitations are based on the maximum discharge in routing the velocity hydrograph, and on the assumption that uniform flow conditions exist in the exit channel.

H. Design Documentation

All dams that require a construction permit application will also require a minimum amount of documentation. The documentation will be commensurate with the dam classification. The State Engineer may require additional information on a case-by-case basis.

The minimum requirements for class I and II dams include:

- site location map;
- drawings showing dam height, top width, side slopes, and the size, location and elevation of the spillways;
- hydrology runoff computations including drainage area, watershed time of concentration, and other information;
- description of soils analysis; and
- specifications or reference to standard specifications.

It is suggested that a Design Documentation Folder be completed for all class III, IV and V dams designed by those engineering organizations and firms involved in dam design in North Dakota. The level of documentation required by the State Engineer in the review of the permits will vary with the dam design class and other factors. The following is an example outline of a Design Documentation Folder.

**DESIGN DOCUMENTATION FOLDER INDEX**

General
- Preliminary Investigation Report
- Structure classification (including a narrative to justify classification)
- Copies of permits

Hydrology
- Watershed map (USGS quad map)
- Runoff infiltration parameter computations
- Time of concentration computations
- Routing parameter computations
- Hydrologic model results
- Historical flood data, if available
- Runoff yield studies, if needed
Hydraulics
- Water surface profiles for tailwater calculations and outlet channel stability check
- Breach routings (class IV and V only)
- Any special routings made for structure evaluation or structure discharges less than the design discharge (For example: check drop spillway design and tailwater at 25, 50 and 75 percent of peak design discharge.)
- Reservoir operation plan, if needed

Geology
- General geology of the area
- Soils explorations
  - centerline of dam
  - conduit location
  - emergency spillway cut
  - borrow area(s)
- Sediment capacity calculations

Soil Mechanics
- Soil mechanics report
- Slope stability analysis
  - Design assumptions (full drawdown upstream, steady seepage downstream or drained downstream slope)
  - Shear strength (from shear testing, correlated from previous dams, based upon geologic descriptions)
- Seepage analysis, as needed
- Foundation settlement (percent consolidation used for each layer)
- Foundation treatment (trench depths, stripping depth, removal of pockets, bedrock treatment)
- Analysis of borrow material (expected compacted values and strengths)

Construction
- compaction and moisture requirements
- specific equipment or construction techniques
- critical inspection points
- Instrumentation of embankment, as needed

Structural Design
- Uplift calculations
- Overturning calculations, if needed
- Structural design calculations (reinforced concrete, steel or wood design)
- Loading checks on standard details
- Pipe joint elongation calculations
- Camber calculations
- Structure instrumentation plans, as needed

Site Protection and Restoration
- Landscape considerations of visual resource and visual resource quality, as needed
- Biological considerations (water quality, wildlife habitat, fish development), as needed
- Vegetation and seeding requirements
- Temporary and permanent erosion control measures

Quantity Calculations
Include quantity calculations for all individual elements including appropriate sketches and cross sections

Project Plans and Specifications
- Bid proposal
- Complete set of construction drawings and specifications
- Engineer’s cost estimate
- Construction schedule
CHAPTER VI:

Modification of Existing Structures

There are several events that might require dam modification. Additional storage may be required for a variety of reasons: modification may be desirable for aesthetic reasons when the area adjacent to the dam has or will become developed; unsafe conditions may have developed in some part of the dam; or compelling new standards are imposed by a regulatory agency. This chapter outlines suggested procedures in investigating modifications to existing structures.

The suggested criteria in Chapter V also applies to the modification of existing dams. It may not be practical, however, to strictly follow the new dam standards with existing structures. Therefore, the State Engineer will consider several factors in the review of existing dams including: the design class and hazard category, the overall safety of the dam prior to and with the modification, and the added cost of the new dam criteria.

A. Land Rights

When the modification of a structure is being considered, the land rights and easements must be thoroughly reviewed for adequacy. Utilities may make new or additional easements necessary, particularly if the area is or has been developed. Additional easements may be required for access roads and for new borrow or disposal areas.

B. Hydrology

The hydrology suggestions outlined in Section B, Chapter V should be followed, if possible, when modifying existing dams. In addition, there are other considerations that are specific to existing dams.

The drainage areas of many existing structures were determined from maps of less detail than the USGS 7½ minute quadrangle maps. Therefore, original drainage area should be reviewed for accuracy. Over the years, diversions may have been constructed, resulting in a larger or smaller drainage area. People enjoy living near water areas and often will construct their homes near reservoirs. This development adds more impervious area such as driveways, parking areas and roofs. This may not only increase the runoff, but may cause a change in peak rates.

Before beginning any hydrologic or hydraulic analysis, a review should be made of any available design records for the dam and spillway. Information such as discharge rating curves or tables, storage capacity, and pertinent dimensions of spillways and outlets should be obtained. Any changes in tailwater condition since the original design should be determined. The procedures used in the design of the spillway(s) should be compared with currently accepted techniques and criteria. If it is evident that the original design basis gave results substantially in accord with current practices, further investigation may be limited to verify that the existing project meets the adopted design objectives. If the results are considerably different from what would be acceptable today, then a revised flood study is required. Storm events that have caused secondary spillway flow during the life of the dam should be analyzed.

If the dam that is proposed for modification stores permanent water for some beneficial use, the reliability of the runoff yield should be reviewed, particularly if additional beneficial storage is to be added.

C. Sediment Storage

A sediment survey of the existing reservoir should be conducted to determine the amount of sediment that has accumulated to date. Future land use should be carefully considered. If the land in the watershed may be developed for residential or other urban uses, strict developmental requirements are needed, or increased storage is needed for sediment allocation. It may be necessary to install sediment basins to reduce sediment delivery to the reservoir.

D. Geological Explorations

The existing embankment and abutments shall be thoroughly examined for cracking, slumping or sloughing and piping. Dye tests or other techniques to locate the source of excessive seeps may be necessary. The downstream area shall be examined for seeps or boils. Borings should be made in the embankment to classify and determine the in-place density of material and the location of the phreatic line. If the dam is to be raised, the original foundation investigation and reports should be thoroughly reviewed for adequacy. If an original foundation report is not available, borings should be made through the embankment and into the foundation to determine its suitability for the increased loadings.

Explorations in the borrow area(s) should be made to determine that there are sufficient quantities available and that the strength and density of the material is adequate. In-place moisture content of the borrow material should be determined.
E. Embankment Design

For embankment dams, the major non-hydraulic causes of failure involve foundation structural instability or foundation seepage stability. Closely associated defects are excessive settlement, slope erosion, malfunctioning drains, problems at the abutments or at the foundation/embankment interface, tree growth, and rodent activity.


If an existing dam is to be modified, the embankment design must be thoroughly reviewed. In all probability, additional height cannot be added without a modification of the slopes. The same is true regarding increasing the top width.

Stability assessments should utilize in situ properties of the structure, its foundation and pertinent geologic information. “As Built” records should be reviewed along with other geologic information.

Geologic information that should be considered includes groundwater and seepage conditions, lithology, stratigraphy, and geologic details. Foundations may present problems where they contain adversely oriented joints, slickensides or fissured material, faults, seams of soft materials, or weak layers. Such defects along with excess pore water pressures may contribute to instability. Special tests may be necessary to determine physical properties of particular materials. The results of stability analyses afford a means of evaluating the structure’s existing resistance to failure and also the effects of any proposed modifications. When possible, results of stability analyses should be reviewed for compatibility with performance experience.

The loading conditions for which the modified or repaired dam should be investigated, along with the minimum factors of safety, are:

1. Rapid drawdown from spillway crest elevation — 1.2.
2. Partial pool with assumed horizontal steady seepage saturation — 1.5.
3. Steady seepage from spillway crest or top of gates with the horizontal permeability to vertical permeability ratio assumed as a minimum of nine — 1.5.
4. Earthquake (cases 2 and 3 with seismic loading) — 1.0.

Modifications to the original seepage design should consider conditions observed in the field inspections and piezometer instrumentation. A seepage analysis should consider the horizontal and vertical permeability ratios resulting from both natural deposition and compaction placement of materials.

The embankment should be carefully examined for activity by burrowing animals. Where the embankment slopes are being modified, the riprap should be removed as well as all of the vegetation. The old slope should be scarified and watered prior to placement of new fill material. Upon completion of the modification the new slope would be seeded and riprapped as appropriate.

F. Principal Spillway Design

The original principal spillway plans should be thoroughly reviewed and field checked to see that the spillway was built as designed. The interior of the principal spillway should be visually inspected by physically entering the conduit or by use of video equipment.

The location and depth of any pools of water should be located on the plans. Pools indicate the absence of camber. The present condition and expected life of the conduit should be noted. Where possible, joint gaps should be measured. If the dam is modified, new joint separation estimates should be calculated.

Inlet modifications shall be carefully planned and designed. When the riser is to be raised, the footings should be checked to see that they are adequate for the additional load. Special attention should be given to the joints between the inlet and the conduit and drawdown facilities.

Barrel repairs or modifications should be commensurate with the importance of the dam. Where damage is sufficiently severe, as when a metal conduit is severely corroded, it may be necessary to remove it and replace it. If the joints have become excessively elongated, it may be necessary to fill the gaps or, in severe cases, to line the entire barrel with a suitable casing.

The outlet conditions should be thoroughly inspected. The scour hole or plunge pool should be measured to determine the amount of lateral extension. If the plunge pool had originally been riprapped, the amount and condition of the riprap should be assessed.

Where the outlet consists of a mechanical energy dissipator, certain elements need careful review. Joint openings should be examined for the integrity of the water stop material. All drains should be examined for defects. The outlet channel should be measured to assure that it will provide the proper tailwater elevation. If modification of the dam would either increase or decrease the principal spillway peak flows, the outlet channel should be reevaluated.

The drawdown facilities should be checked to determine whether the gate seals and operates in a smooth manner. When drawdown facilities are to be added, care should be taken so the hydraulics are compatible with the existing system.

G. Emergency Spillway Design

If the dam is modified, it may be necessary to completely renovate the emergency spillway system. The vegetative cover should be retained, if possible, particularly in the exit section. If evidence of gullying is observed, transverse barriers of erosion resistant material should be installed. If meandering has taken place on the emergency spillway floor, small (4" to 9" high) lateral dikes should be installed. The original freeboard and emergency spillway hydrographs should be reviewed and updated prior to routing through the structure.

H. Design Documentation

Design documentation for modifying existing structures should be as thorough as for new dam design. The design documentation contained in Chapter V, Section H, is suggested.
CHAPTER VII:

Construction Drawings and Specifications

This chapter sets forth the suggested formats for construction drawings and specifications. Design classification I and II dams require less detailed drawings and specifications. For small dams, the SCS uses a hydraulic data sheet for construction drawings (Form ND-ENG-16), and a small booklet for specifications. Form ND-ENG-16 is included in Appendix B. Design class III, IV, and V dams require detailed drawings and specifications. The following two sections are suggested outlines of information to be included on the construction drawings and in the specifications.

A. Construction Drawings

1. Cover sheet
   a. title of the project
   b. site location map
   c. list of cooperators and/or sponsors
   d. generally physical informational data such as drainage area, height, etc.
   e. index of drawings
   f. signature block

2. Watershed Boundary Map
   a. structures located and identified, including existing structures
   b. farm boundaries
   c. landowners' names
   d. watershed boundary
   e. north arrow and scale
   f. section, township and range numbers
   g. existing roads and highway numbers

3. Site Maps
   a. plan view of site including embankment, emergency spillway, and reservoir area
   b. topography of structure site including all topographic features
   c. land ownership
   d. base lines
   e. centerline of embankment and emergency spillway
   f. property lines and fence lines
   g. construction limits
   h. utility lines and pipelines
   i. roads, highways and railroads (with names)
   j. bench marks
   k. borrow areas and waste areas
   l. clearing and grubbing areas
   m. waterways, diversions, and channel improvements
   n. wells
   o. fence removal and/or construction
   p. scale and north arrow

4. Plan View Sheets
   a. plan view of structure site including embankment, principal spillway and emergency spillway
   b. topography of structure site including all topographic features
   c. stationing along centerline of dam and emergency spillway
   d. cross sections
   e. soil borings
   f. embankment drainage
   g. sodding areas
   h. topsoil spreading areas
   i. scale and north arrow

5. Profile Sheets
   a. embankment
   b. principal spillway
   c. emergency spillway
   d. channel improvement, waterways, and diversions
   e. outlet channel
   f. structural drainage system

6. Cross-Section Sheets
   a. embankment and trenches
   b. emergency spillway
   c. borrow area
   d. outlet channel
   e. soil borings
   f. structural drainage system

7. Structural Detail Sheets
   a. structure layout
   b. principal spillway
   c. barrel and appurtenances
   d. inlet-riser, trash rack, safety guard
   e. drainage system
   f. fence layout and details

8. Standard Detail Sheets

9. Topography for Erosion Control During Construction
   a. temporary and permanent diversions
   b. bypass channels and sediment traps
   c. sediment basins and grade control structures

10. Details for Erosion Control During Construction
    a. profile for diversion and bypass channels
    b. typical cross sections of diversions, channels, structures and dikes
    c. sections along centerline of principal spillway for all sediment and erosion control structures
    d. vertical inlet details if needed
B. Specifications

Standard specifications of the U.S. Soil Conservation Service and the North Dakota State Water Commission may be utilized in the preparation of specifications. The specifications will be in the form of a booklet with a cover that identifies the structure, its location, the owner, the name of the preparer and the date.

The first inside sheet is an index list of construction and material specifications. The specifications booklet may incorporate special provisions and other contract details. The specifications may incorporate, by reference, "Standard Specifications for Water Resource Facilities," (North Dakota State Water Commission), as well as ASTM, ASSHTO or other appropriate specifications. It is also recommended that an "Items of Work and Construction Details Section," be included that shows details not covered in the reference specifications, such as methods of measuring quantities. The specifications should be numbered in a manner that can be readily followed by the contractor and inspection personnel during construction operations.
CHAPTER VIII:

Construction Inspections, Records and Completion Documents

The purpose of this chapter is to provide general information on construction inspection, record keeping and completion documents. In many regards, these requirements may be the most important part of dam construction. The best design and specifications mean little if they are not adhered to during construction and documented after construction.

A. Inspections

1. Construction Work Inspections

Construction inspections ensure that the work complies with the project design and specifications. The level of inspection is dependent upon the design classification of the dam and on the type of work being performed. A construction inspected plan will be required for all class IV and V dams. Design classification III, IV and V dams may require continuous inspections, whereas class I and II dams may require only periodic inspections. The level of inspections can also vary with different construction phases. Continuous inspections are suggested for any work in which the quality cannot be accurately determined after the fact and for any work that cannot be readily replaced if rejected. The engineer-designer should designate those items that are to receive full-time inspection. Work items of this type include (but are not limited to): foundation excavation in which depth must be determined during the course of work, foundation excavation underwater, pile driving, placing compacted earth fill, structural backfill, placing drain fill and filters, placing riprap, placing and bedding pipe, mixing and placing concrete and pneumatically applied mortar, mixing and placing asphalitic concrete, installing relief wells, and performing acceptance tests of machinery and equipment.

Periodic inspection may suffice for certain other types of work, depending on circumstances prevailing at a site. Works of this type may include (but are not limited to): dewatering the work site, clearing, clearing and grubbing, stripping, structure removal, open channel excavation, borrow pit excavation, form construction, placement of steel reinforcement, metal fabrication, timber fabrication, installing water control gates, painting, installing fences, sodding, mulching, and general cleanup. It must be recognized that continuous inspection of such items may be required because of local complications, such as complex site conditions, erratic soil deposits, remote site location, nature of the construction schedule, or contractor’s attitude or ability.

The number of samples to be taken and tested varies with the material, the amounts being placed during a designated period, the results of previous tests and the experience and qualifications of the contractor and his work force. In general, concrete and earthwork are the two primary categories that require samples and/or tests.

Concrete requires at least three test cylinders, one slump test and one air entrainment test for each pour. As a guideline, samples should be taken (at random) from at least one third of the redi mix or batch mix delivered to the site. If past test results show borderline strengths and/or air content, etc., each batch should be sampled until the engineer and inspector are satisfied that the quality is satisfactory and uniform.

Earthwork tests are dependent upon the design classification of the dam. The specifications for a class I or II dam may call for machine compaction and visual inspection by a competent inspector. A class III dam may require density and moisture control. At least two moisture density tests should be run per day, averaging one test per 400 to 500 yards.

A large class IV or V dam may have six or more hauling units, with placement of several thousand yards per day. A systematic program of field compaction control should be established and executed, involving determinations of compaction densities and water contents. Sufficient density and moisture tests must be taken to verify the adequate compaction and uniform moisture distribution for each lift during placement and compaction operations. Special emphasis may be required for critical zones within a zoned embankment.

Careful inspection of backfill around imbedded items such as pipe is required on all classes of dams.

Information on inspection, sampling, testing and recording forms are available from numerous sources, including the SWC and the SCS.

2. Material Inspection

Materials used in the construction of earth dams generally fall into one of three categories:

(a) manufactured material such as pipe, reinforcing steel, etc.;

(b) concrete including aggregate, cement, water and admixtures; and

(c) natural materials such as earthfill, sand, gravel, rock riprap, sod and grass seed.

Most manufactured products, including concrete admixtures and cement materials, may be accepted based on certifications furnished by the manufacturer. The manufacturer is to furnish, on request, certifications and test results on the material(s) in question.

Inspection at the factory may be required for special items or major items of mechanical or electrical equip-
ment. Inspection at or near the site of work is required for all materials and work for which compliance with specification requirements can be partially or completely verified by on-site examination and testing. This inspection may take the form of:

(a) examinations, measurements, and tests performed by an inspector at the site of work;
(b) laboratory testing of samples of materials obtained or prepared at the site of work, or at local points of supply; and
(c) periodic inspection of local concrete mixing plants, including operation of these plants.

Some materials must be inspected at the work site. They are:

(a) earthfill materials, rock for fill or riprap, aggregates for concrete or asphaltic concrete, and drain fill materials;
(b) upgraded wood products (such as round timber, wood piles, and posts);
(c) materials manufactured at or near the site of work (such as concrete, pneumatically applied mortar, asphaltic concrete, and concrete piles); and
(d) any other materials such as vegetative materials that may not be accepted on the basis of certification.

3. State Engineer Monitoring

The State Engineer (or designee) will make frequent inspections to determine progress and conformance to construction drawings and specifications. When requested by the consulting engineer or local sponsoring agency, the State Engineer will consider, on a project-by-project basis, uniform scheduling of construction reviews.

Failure of the contractor to conform to the drawings and/or specifications for any cause on any structure may cause rejection and removal of that portion of the work failing to meet requirements. When the SWC is involved in cost-sharing on a project, an agreement between the local sponsors and the SWC shall be executed prior to contract award, setting forth the responsibilities of each — financially and physically — in monitoring the construction of the dam.

B. Records

1. Job Diary

A job diary is to be maintained for each dam to provide a history of the work. Entries are to be made daily or, when continuous inspection is not required, whenever the engineer or inspector are on the job.

Bound job diaries will be required on all dams where a formal contract is entered into between the contractor and the local sponsors and/or the SWC. The SCS uses a bound job diary which may prove of value as a guide. (See Appendix C for example format.)

The job diary is the pertinent history of the project, beginning with the showing of the site to prospective bidders, and concluding with the completion of the job. The diary should be on hand at all times and entries should be completed as the events occur. The following items should be recorded in the job diary on a daily basis: weather, work hours, work force, equipment on site and used, work completed, tests, time delays, cause of delays, rejected work, problems, instructions given to the contractor, job-related visitors, and other significant items.

Photographs are an extremely important part of construction inspections and documentation. It is necessary to have photographic documentation of significant construction conditions, deficiencies, and safety or health violations. Photographs may be included as supplemental information on the job diary.

2. Change Orders

During the progress of the work, the engineer or technician in charge of construction must be sensitive to developments that seem to be significantly different from those assumed in the design. When these developments occur, construction inspection personnel are not to alter the design or allow the contractor to continue construction, until the individual with design approval authority has evaluated the condition and made any adjustments necessary in the plans and specifications.

The contractor should not be allowed to proceed with any of the changed work until a written change order has been approved by the appropriate person(s). (See SWC Form No. 194, Appendix C.) When the SWC is cost-sharing, the project agreement shall designate those persons with authority to execute change orders.

C. Completion Documents

1. As-Built Plans

As-built plans that represent the structure as it was actually constructed may be necessary: to evaluate the structure’s design and operation, to provide evidence in legal matters, and to facilitate efficient maintenance or modification. As-built plans and completion reports are suggested for all design class III, IV and V dams. The importance of as-built plans cannot be overemphasized. Often the only information available on certain components is what is shown on the as-built plans. The minimum requirement of as-built plans is a documentation of all changes that are not clearly visible after construction.

A complete set of full-size construction plans should be kept at the work site for recording changes. All changes during construction must be recorded on the drawings to indicate as-built conditions. If a structure is altered at any time after its completion, the as-built plans are to be retrieved and revised to indicate the alterations and then are to be processed in the same way as original as-built plans.

Structural or dimensional changes are to be illustrated in detail in order to provide a complete, readable, and true record. Upon completion of the project, the elevations of several of the structural components should be shown including the inlet and outlet structures and the foundation drain outlets. The elevation and gap measurements of the joints in the principal spillway conduit should be shown at the time of installation.

Geologic conditions revealed during construction that differ significantly from those in the geologic
report are to be recorded on the as-built plans. Examples of differences are elevation of rock surfaces, type of rock or soil, joint orientation and openings, or ground-water elevation.

As-built geology should also include:
(a) as-built profile of the core trench;
(b) as-built profile of the pipe trench; and
(c) changes in materials different from those indicated by the logs on the geologic profile shown on the plans for construction. This would include, but is not limited to, borrow, core trench, pipe trench, drains, etc.

It is also recommended that the as-built include a detailed description of the vertical and horizontal control points. These points should be plotted on the appropriate sheets.

The as-built plans should be certified by the design engineer. Copies of the as-built plans shall be furnished to the State Engineer and the primary local sponsoring organization having the responsibility for operation and maintenance.

2. Completion Report
A completion report should be prepared for all class III, IV and V design dams. The report should be in narrative form, giving a chronological history (including pictures or slides) of the construction of the dam, starting with the date of award and the name of successful contractor. It should include a short description of problems encountered, solutions to the problems and any other pertinent information.
CHAPTER IX:

Operations, Inspections and Maintenance

The designer shall prepare an Operation and Maintenance (O&M) plan for all design class III, IV and V dams. The O&M plan shall be tailored to the specific dam. It will generally not be necessary to provide a detailed O&M plan for design class I and II dams. The following should be considered in the preparation of an O&M plan.

OPERATIONS AND MAINTENANCE PLAN

I. OPERATIONS
The owner will be responsible for operating the dam in compliance with applicable federal, state and local laws.

II. INSPECTIONS
There are two types of dam inspections. Routine inspections are directed at observing changes from the as-built condition. Post storm or emergency inspections are directed at surveying storm damages and/or possible deficiencies.

All inspections are the responsibility of the owner(s) and must be made by properly trained people. In general, it is recommended that a design class III dam be inspected every two years, and class IV and V dams once a year. In addition, all dams should be inspected if the emergency spillway is used, or if possible deficiencies are noted. The designer should develop an inspection checklist for the dam (see Appendix D). It is suggested the State Engineer be contacted for possible assistance prior to the inspection of a class III, IV or V dam. All monitoring instruments should be read and the results recorded.

III. MAINTENANCE
The Operation and Maintenance Plan should include specific maintenance measures for the dam. The maintenance measures should be consistent with the dam’s original design and the as-built conditions. The maintenance plans should address:
1. vegetation,
2. embankment and structural items,
3. materials,
4. photograph documentation, and
5. monitoring instruments.
CHAPTER X:

Emergency Action Plans

It is intended that the guidelines for the design, construction, operation and maintenance, and inspection of dams will minimize the risk of future dam failures. Nevertheless, it must be recognized that despite the adequacy of dam design guidelines and their implementation, the possibility of dam failure still exists. Although the probability of failure is small, pre-planning is required to identify conditions which could lead to failure and to minimize the extent and effects of a failure. This section describes recommended procedures for reacting to an emergency or unsafe condition created by the threat of a dam failure. The action categories and other recommendations listed are only general guidelines. The owner and design engineer should develop an Emergency Action Plan and make a determination of the Categories of Action. The owner should periodically update the action plan.

This section is based on three primary suggestions: The first is that an Emergency Action Plan be developed for all classes of dams. The level of detail included in each plan should be commensurate with the hazard category of the dam. The second suggestion is that two Categories of Action be developed that trigger action by the dam owner. Conditions listed as “Category of Action I” are considered extremely severe occurrences that present an immediate danger to the dam and to downstream areas. Therefore, any Category I condition should immediately activate the Emergency Action Plan. The conditions listed as “Category of Action II” present a potential, but not necessarily immediate, danger to the structure. The Category II conditions could, however, develop into a more serious problem. Therefore, a qualified engineer should be immediately notified and a prompt inspection should be made of any structure with Category II conditions. Examples of Categories of Action are listed in Appendix E.

The third recommendation is that the dam owners and dam design engineers coordinate with the appropriate local emergency management organization. This coordination will ensure that the Emergency Action Plan properly interfaces with local emergency operations warning plans and with local government response and support activities. The State Division of Emergency Management can provide general guidance in the preparation of the plan.

An Emergency Action Plan is a clear, concise plan of action to be followed in the event of a failure or an impending dam failure. Any condition listed as Category of Action I should automatically activate the Emergency Action Plan. The dam owner is responsible for drafting the plan, providing copies to the participants and activating the plan.

A. Emergency Action Plan
(Class I and II Dams)

An Emergency Action Plan for design class I and II dams may be only a notification list of individuals and agencies to be contacted upon dam failure. The plan should contain the names, addresses and phone numbers of a few key contacts. At a minimum, the list should include the local water resource board, the Office of State Engineer, the engineering firm or agency that designed the structure (if applicable), the State Division of Emergency Management, the local emergency management coordinator, and downstream landowners that may be affected.

B. Emergency Action Plan
(Class III and IV Dams)

The Emergency Action Plan for class III and IV dams includes a downstream inundation map, a detailed notification list and a list of contractors and others that could provide assistance during a failure or a possible failure condition. The notification list should include downstream residents (listed in order beginning with those affected first), the dam design engineer or agency, the local water resource board, the Office of State Engineer, State Division of Emergency Management, the local emergency management coordinator, and various other emergency services. A sample directory is included in Appendix E.

The list of downstream residents with phone numbers should be shown on a downstream inundation map. The map should be equivalent to the USGS 7½ minute quadrangle maps. The map should extend a minimum distance of 10 miles downstream or until the stream enters a significantly larger stream or river that would quickly attenuate the flood levels. The map should show the locations of residents indexed to the notification directory, along with roads, bridges and anything else that may suffer significant damage because of a dam break.

C. Emergency Action Plan
(Class V Dams)

The Emergency Action Plan for a design class V dam needs to be adequately detailed, well-organized and well-prepared. The notification directory needs to be completed in detail. The inundation map needs to be based on the results of a dam break routing procedure. The routing procedure must extend downstream to a
point where the floodwaters are within the channel banks or the threat of resident inundation no longer exists. The inundation map for class V dams should be adequately detailed, identifying dwellings and significant features that are likely to be affected. The maps should also show the estimated travel time and depth at selected locations.

Downstream warning systems should be considered for all design class V dams, with the precise procedure detailed in the Emergency Action Plan. Existing local government emergency operation plans for warning should be consulted for proper interface and inclusion of downstream warning procedures. The plan should be reviewed with downstream individuals and entities.

The Emergency Action Plan Directory must be reviewed and updated, if necessary, on a yearly basis by the dam owner. The North Dakota Division of Emergency Management should be furnished an annual status report of the Emergency Action Plan Directory, including modifications.
ABUTMENT — The part of the valley side against which the dam is constructed. Right and left abutments are those on respective sides of an observer when viewed looking downstream.

ANNUAL RUNOFF — The total discharge of a stream for a year, usually expressed in inches, depth or acre-feet.

ANTECEDENT MOISTURE CONDITION (AMC) — The degree of wetness of the soil in a watershed at the beginning of a storm. (See Section 4, National Engineering Handbook, SCS.)

ANTI-SEEP COLLAR — A projecting collar, usually of concrete, built around the outside of a pipe, tunnel, or conduit, under an embankment dam, to lengthen the seepage path along the outer surface of the conduit.

AXIS OF DAM — The plane or curved surface, arbitrarily chosen by a designer, appearing as a line, in plan or in cross section, to which the horizontal dimensions of the dam can be referred.

BACKWATER — The resulting high water surface in a given stream due to a downstream restriction or a high stage in an intersecting stream.

BAFFLE BLOCK — A block of concrete or concrete and steel constructed in a channel or a stilling basin to dissipate the energy of water flowing at a high velocity.

BASE WIDTH — The maximum thickness or width of a dam measured horizontally between upstream and downstream faces, and normal to the axis of the dam, but excluding projections for outlets, etc.

BASE FLOW — The sustained discharge which persists after storm runoff has been depleted. It is usually derived from ground-water discharge or gradual snow or ice melt over extended periods of time, but need not be continuous flow.

BERM — A horizontal step or bench in the sloping profile of an embankment dam.

BLANKET —

DRAINAGE BLANKET — A drainage layer placed directly over the foundation material.

GROUT BLANKET — Consolidating a layer of the foundation to achieve greater impermeability and/or strength by injecting grout.

UPSTREAM BLANKET — An impervious layer placed on the reservoir floor or on the abutments upstream of a dam. In the case of an embankment dam, the blanket may be connected to the impermeable element in the dam.

CONDUIT — A closed channel to convey the discharge through or under a dam.

CONDUIT FILTER DRAIN — A pervious filter drain around a conduit for the purpose of seepage control. The filter drain is often tied into other drain systems in the foundation or embankment. It is an alternative to anti-seep collars.

CONSERVATION STORAGE — The water that is impounded for consumptive uses such as municipal, industrial, irrigation, stockwater and non-consumptive uses such as lake evaporation and seepage. Conservation storage does not include flood or sediment storage.

COFFERDAM — A temporary structure enclosing all or part of the construction area so that construction can proceed in the dry. A diversion cofferdam diverts a river into a pipe, channel, or tunnel.

CONTROL SECTION — The section where flow passes through critical depth.

CORE (IMPERVIOUS CORE) (IMPERVIOUS ZONE) — A zone of material of low permeability in an embankment dam; hence the terms central core, inclined core, puddle clay core, and rolled clay core.

CREST LENGTH — The developed length of the top of the dam.

DAM — An artificial barrier, together with any associated spillways and appurtenant works, across a watercourse or natural drainage area, which does or may impound or divert water.

DAM HEIGHT — The distance between the stream channel bottom at the centerline of the dam to the top of the settled embankment.

DAMAGE REACH — A length of floodplain or valley selected for damage evaluation.

DEAD STORAGE — The storage that lies below the invert of the lowest outlet and that, therefore, cannot be withdrawn from the reservoir without pumping.

DESIGN LIFE — A period of time during which a dam is designed to perform its assigned functions satisfactorily.

DIAPHRAGM — A cutoff wall, or core wall, made of relatively impervious material such as asphaltic concrete, concrete, or earth.

DRAINAGE AREA (WATERSHED) — The area that drains naturally to a particular point on a river, stream or creek.

DRAINAGE WELLS (PRESSURE RELIEF WELLS) — Vertical wells or boreholes usually downstream of impervious cores, grout curtains, or cutoffs, designed to collect and control seepage through or under a dam, so as to reduce uplift pressures under or within a dam. A line of such wells forms a drainage curtain.
DRAWDOWN — The lowering of water surface level due to release of water from the reservoir.

DRAWDOWN PIPE — A pipe through the embankment that allows for water releases below the principal spillway level.

DRY DAM (DETENTION DAM) — A dam that has an un gated outlet positioned so that essentially all stored water will be drained from the reservoir by gravity. The reservoir will normally be dry.

ECONOMIC LIFE — The period of time during which economic benefits accrue to a dam.

EARTHFILL DAM — A dam constructed of excavated natural earth material obtained from a borrow area.

HOMOGENEOUS EARTHFILL DAM — A dam constructed of similar earth material throughout, except for possible inclusion of internal drains or drainage blankets. Used to differentiate from a zoned earthfill dam.

ZONED EARTHFILL DAM — A dam, the thickness of which is composed of zones of selected material having different degrees of porosity, permeability, and density.

EMERGENCY ACTION PLAN — A predetermined plan of action to be taken to reduce the potential for property damage and loss of lives in an area affected by a dam break.

EMERGENCY SPILLWAY (SECONDARY) — The spillway designed to convey excess water through, over or around a dam.

EMERGENCY SPILLWAY SYSTEM — A single emergency spillway or combination of emergency spillways designed to work together.

EXIT CHANNEL — An open channel spillway, located downstream from the control section, which conducts the flow to a point where it may be released without jeopardizing the dam.

FACE — With reference to a structure, the external surface that limits the structure, e.g., the face of a wall or a dam.

FETCH — The straight line distance between a dam and the farthest reservoir shore. The fetch is one of the factors used in calculating wave heights in a reservoir.

FILTER (FILTER ZONE) — A band or zone of granular material that is incorporated in a dam and is graded (either naturally or by selection) so as to allow seepage to flow across or down the filter without causing the migration of material from zones adjacent to the filter.

FLASHBOARDS — Lengths of timber, concrete, or steel placed on the crest of a spillway to raise the retention water level but that may be quickly removed in the event of a flood, either by a tripping device or by a deliberately designed failure of the flashboards or their supports.

FLOOD FREQUENCY — An expression or measure of how often a hydrologic event of a given size or magnitude should, on average, be equaled or exceeded. For example, a 50-year frequency flood (two percent chance) should be equaled or exceeded, on the average, once in 50 years.

FLOODPLAIN — An area adjoining a body of water or natural stream that has been or may be covered by floodwater.

FLOOD ROUTING — Computation of the changes in the rise and fall in stream flow as a flood moves downstream. The results provide hydrographs of flow versus time at given points on the stream or in a reservoir.

FLOOD STAGE — The stage or elevation in which overflow of the natural banks of a stream or body of water begins in the reach or area.

FLOOD STORAGE — Floodwater storage in a reservoir. In a floodwater retarding reservoir, the temporary storage between the crests of the principal and emergency spillways.

FOUNDATION OF DAM — The natural material on which the dam structure is placed.

FREEBOARD HYDROGRAPH — The hydrograph used to establish the minimum settled elevation of the top of the dam. It is also used to evaluate the structural integrity of the spillway system.

GROIN — That area along the contact (or intersection) of the face of a dam with the abutments.

GROSS STORAGE CAPACITY — The gross capacity of a reservoir from the river bed up to maximum controlled retention water level. It includes active, inactive, and dead storage.

GROUT CAP — A concrete pad or wall constructed to facilitate subsequent pressure grouting of the grout curtain beneath the grout cap.

GROUT CURTAIN — A barrier to reduce seepage under a dam, produced by injecting grout into a vertical zone, usually narrow in horizontal width, in the foundation.

HYDROGRAPH — A graphical representation of discharge, stage, volume, or other hydraulic property (with respect to time) for a particular point on a stream.

HYDROLOGIC SOIL-COVER COMPLEX (CURVE NUMBER) — A combination of hydrologic soil group and a type of cover. Each complex is assigned a runoff curve number (CN) that indicates that runoff potential.

HYDROLOGIC SOIL GROUP — A group of soils having the same runoff potential under similar storm and cover conditions.

INLET CHANNEL — An open channel in a spillway system upstream from the control section.

JOINT EXTENSIBILITY — The amount a pipe joint can be extended from the fully engaged position without losing strength or watertightness. In case of rubber gasket joints, it is measured from the center of the gasket to the point of flare of the bell ring (or collar) when the joint is fully closed.

JOINT GAP — The longitudinal dimension between the end face of the spigot end of a pipe joint and the corresponding face of the bell end of the connecting pipe. It does not include the beveled portion designed for sealing compounds.

LAG (OR LAG TIME) — The time from the centroid of rainfall to the peak of the hydrograph. It can be estimated from time of concentration as 0.6T_c.

LOW-LEVEL OUTLET — A gated opening from the reservoir, generally used for lowering the reservoir or for providing downstream releases.

MAXIMUM WATER LEVEL — The maximum water level, including the flood surcharge the dam is designed to withstand.
MINIMUM OPERATING LEVEL — The lowest level to which the reservoir is drawn down under normal operating conditions. The lower limit of active storage.

NAPPE — The free-falling stream from a weir or spillway.

NORMAL WATER LEVEL — For a reservoir with a fixed overflow sill, it is the water level at the lowest un gated spillway sill. For a reservoir which is controlled wholly or partly by movable gates, or by other means, it is the maximum water level under normal operation conditions.

PEAK FLOW — The maximum instantaneous discharge that occurs during a flood. It is coincident with the peak of a flood hydrograph.

PERMANENT STORAGE — Water impounded for consumptive uses such as municipal, industrial, irrigation, stockwater; and non-consumptive uses such as recreation, and fish and wildlife, including the storage lying below the lowest un gated outlet.

PERVIOUS ZONE — A part of the cross section of an embankment dam comprising material of high permeability.

PHREATIC SURFACE — The free surface of ground water at atmospheric pressure.

PIEZOMETER — An instrument for measuring pore water pressure within soil, rock, or concrete.

PIPING — The progressive development of internal erosion by seepage, appearing downstream as a hole or seam discharging water that contains soil particles.

PLUNGE BASIN (PLUNGE POOL) — A natural or sometimes artificially created pool that dissipates the energy of free-falling water.

PRINCIPAL SPILLWAY — The lowest un gated spillway designed to convey water from the reservoir at uncontrolled release rates.

PRINCIPAL SPILLWAY HYDROGRAPH — The hydrograph used to determine the minimum crest elevation of the emergency spillway. It is used to establish the principal spillway capacity, and to determine the associated minimum floodwater retarding storage.

PROBABLE MAXIMUM FLOOD (PMF) — The flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are possible in the region.

PROBABLE MAXIMUM PRECIPITATION (PMP) — The maximum amount of precipitation that can be expected to occur on a drainage basin for varying durations.

RETARDING OR DETENTION POOL — The portion of the reservoir allotted to the temporary impoundment of floodwater. Its upper limit is the elevation of the crest of the emergency spillway.

RESERVOIR AREA — The surface area of a reservoir when filled to a controlled retention water level.

RIPRAP — A layer of large stones, broken rock, or precast blocks placed in random fashion on the upstream slope of an embankment dam, on a reservoir shore, or on the sides of a channel, as a protection against wave and ice action.

RISK ASSESSMENT — As applied to dam safety, the process of identifying the likelihood and consequences of dam failure to provide the basis for informed decisions on a course of action.

RUNOFF YIELD — The portion of precipitation (including snowmelt) that flows across the land surface and contributes to stream or flood flow.

SEDIMENT STORAGE — The portion of the reservoir allotted to the accumulation of submerged sediment during the design life of the dam.

SLOPE PROTECTION — The protection of an embankment slope against wave action or erosion.

SLURRY TRENCH — A narrow excavation whose sides are supported by a slurry made of mud, clay, or cement and mud, filling the excavation. Sometimes used to describe the cutoff itself.

SPILLWAY — An open or closed channel, conduit or drop structure used to convey water from a reservoir. It may contain gates, either manually or automatically controlled, to regulate the discharge of water.

STILLING BASIN — A basin constructed so as to dissipate the energy of fast-flowing water, e.g., from a spillway or bottom outlet, and to protect the river bed from erosion.

STOPLOGS — Large logs or timbers or steel beams placed on top of each other with their ends held in guides on each side of a channel or conduit.

STORAGE — The capacity of the reservoir below the elevation of the crest of the emergency spillway.

STORAGE INDICATION METHOD — A name often given to a flood-routing method also often called the Puls method (after Louis G. Puls) — though it is actually a variation of the method devised by Puls.

STREAM REACH — A length of stream channel selected for use in hydraulic or other computations.

STRUCTURAL HEIGHT — The distance between the lowest point in the excavated foundation (excluding narrow fault zones) and the top of the dam.

TIME OF CONCENTRATION (Tc) — The time it takes water from the most distant point (hydraulically) to reach a watershed outlet. Tc varies, but it is often used as a constant.

TOE OF DAM — The junction of the dam with the ground surface. For an embankment dam, the junction of the upstream face with ground surface is called the upstream toe, and the junction of the downstream face with the ground is referred to as the downstream toe.

TOP OF DAM — The elevation of the uppermost surface of a dam.

TOP WIDTH — The thickness or width of the top of the dam.

TRASH RACK — A screen located at an intake to prevent the ingress of floating or submerged debris.

UNGATED OUTLET — The outlet that allows uncontrolled flow through, around or over a dam, e.g., the crest of a weir box, the invert of a pipe inlet, or the crest of the emergency spillway on a dam without a principal spillway.

UPLIFT — (a) The upward water pressure in the pores of a material or on the base of a structure, (b) An upward force caused by frost heave or wind force.

VELOCITY SPILLWAY HYDROGRAPH — The hydrograph used to establish the dimensions of the emergency spillway.

VEGETATED SPILLWAY — The vegetated open channel spillway in earth materials.
WATERSHED COMPUTER MODEL — A mathematical representation of a drainage basin within which flood flows are computed with the aid of a computer. Represents the flow process over time using time steps.

WEIR — A wall structure built across a stream or incorporated into the inlet portion of the principal spillway of a dam to maintain an upstream water level.
CHAPTER XII:

Bibliography

A. General References

B. Emergency Action Plan Reference

C. Hydrology and Hydraulics References

D. Maintenance References
- U.S. Army Corps of Engineers, "Recommended Guidelines for Safety Inspection of Dams."

E. Soils and Embankment Design References
- American Society for Testing and Materials
  - Designation C-127 — Specific Gravity and Absorption of Coarse Aggregate.
  - Designation D-422 — Particle Size, Analysis of Soils, Hydrometer.
  - Designation D-854 — Specific Gravity of Soils.
  - Designation D-2166 — Unconfined Compressive Strength of Cohesive Soils.
  - Designation D-2435 — One Dimensional Consolidation Properties of Soils.
  - Designation D-2850 — Unconsolidated, Undrained Strength of Cohesive Soils in Triaxial Compression.
  - Designation D-3080 — Direct Shear Test of Soils.
- U.S. Soil Conservation Service, "National Engineering Handbook Section 8, Engineering Geology."
F. Structural, Concrete and Steel References

APPENDIX A

1. Application for Permit to Construct or Enlarge a Dam or Reservoir

2. Application for Conditional Water Permit
APPLICATION / NOTIFICATION TO CONSTRUCT OR MODIFY DAM, DIKE, RING DIKE OR OTHER WATER RESOURCE FACILITY

Office of State Engineer
900 East Boulevard - Bismarck, ND 58505
SFN 51695 (6-98)

I, the undersigned, do hereby submit the following information to the Office of the State Engineer for their determination and use as a filing of information required under North Dakota Century Code 61-04-02 or as an application to construct or modify a facility under NDCC 61-16.1-38.

No.

OFFICIAL USE ONLY

A. GENERAL INFORMATION:

(1) This Application/Notification must include a map from an actual survey, aerial photo or topographic map. The size of the map shall be 8 1/2 by 11 inches. The map shall have a north arrow and approx. scale. If, in the opinion of the State Engineer, the map does not contain information to properly evaluate the project, it will be returned.

(2) The proposed facility is:

☐ Dam (Complete Section A & B) ☐ Stock Pond (Complete Section A & E)

☐ Dike (Complete Section A & C) ☐ Lagoon/waste storage ponds (Complete Section A & E)

☐ Ring Dike (Complete Section A & C) ☐ Sediment Pond (Complete Section A & E)

☐ Diversion Ditch (Complete Section A & E) ☐ Creations (Complete Section A & B)

☐ Restoration (Complete Section A & D) ☐ Other (Complete Section A & E)

(3) Is this Application/Notification for modification of an existing structure? ☐ Yes ☐ No

If so, when was existing structure constructed? ____________________________ By whom ____________________________

(4) Project Located in ________________________________ Water Resource District.

(5) Legal description to the nearest forty-acre tract: _______1/4 _______1/4 Sec. _______ Twp. _______ Rge. _______

(Optional) Latitude _______________ Longitude _______________

(6) Is the dam and reservoir, dike, diversion ditch, lagoon/pond entirely on Applicant's land? ☐ Yes ☐ No

(if not, applicant must have landowner's permission to construct facility or structure.

Copies of all easements should be filed with these application/notification sheets.)

(7) The facility will be built under the supervision of ____________________________

and will conform to the attached.

(8) Waterway on which structure is or will be located:

(9) A tributary to: ____________________________

NDCC:

61-16.1-38. Permit to construct or modify dam, dike, or other device required - Penalty - Emergency.

No dikes, dams, or other devices for water conservation, flood control regulation, watershed improvement, or storage of water which are capable of retaining, obstructing, or diverting more than twelve and one-half acre-feet [15418.52 cubic meters] of water may be constructed within any district except in accordance with the provisions of this chapter. An application for the construction of any dike, dam, or other device, along with complete plans and specifications, must be presented first to the state engineer. After receipt, the state engineer shall consider the application in such detail as the state engineer deems necessary and proper. The state engineer shall refuse to allow the construction of any unsafe or improper dike, dam, or other device which would interfere with the orderly control of the water resources of the district, or may order such changes, conditions, or modifications as are in the judgment of the state engineer may be necessary for the safety or the protection of property. Within forty-five days after receipt of the application, except in unique or complex situations, the state engineer shall complete the state engineer's initial review of the application and forward the application, along with any changes, conditions, or modifications to the state engineer. If the application meets with the board's approval, the board shall forward the approved application to the state engineer. The state engineer shall make the final decision on the application and forward that decision to the applicant and the local water resource board. The state engineer may issue temporary permits for dikes, dams, or other devices in cases of an emergency. Any person constructing a dam, dike, or other device, which is capable of retaining, obstructing, or diverting more than twelve and one-half acre-feet [15418.52 cubic meters] of water, without first securing a permit to do so, as required by this section, is liable for all damages proximately caused by the dam, dike, or other device, and is guilty of a class B misdemeanor.

61-04-02. Permit for beneficial use of water required.

Any person, before commencing any construction for the purpose of appropriating waters of the state or before taking waters of the state from any constructed works, shall first secure a water permit from the state engineer unless such construction or taking from such constructed works is for domestic or livestock purposes or for fish, wildlife, and other recreational uses or unless otherwise provided by law. However, immediately upon completing any constructed works for domestic or livestock purposes or for fish, wildlife, and other recreational uses the water user shall notify the state engineer of the location and acre-feet [1533.48 cubic meters] of water or the construction of a well from which more than twelve and one-half acre-feet [15418.52 cubic meters] of water is being used. No person shall secure a water permit for constructing an impoundment capable of retaining more than twelve and one-half acre-feet [15418.52 cubic meters] of water or the construction of a well from which more than twelve and one-half acre-feet [15418.52 cubic meters] of water per year will be appropriated. In those cases where a permit is not required of a landowner or the landowner's lessee to appropriate less than twelve and one-half acre-feet [15418.52 cubic meters] of water from any source for domestic or livestock purposes or for fish, wildlife, and other recreational uses, those appropriators may apply for water permits in order to clearly establish a priority date; the state engineer may waive any fees or hearing for such applications. An applicant for a water permit to irrigate need not be the owner of the land to be irrigated.
B. DAMS:

(1) Drainage area above dam ______________ sq. mi. ______________ acres

(2) Purpose: __________________________________________

(3) Geometric description of dam
   a. Maximum height (H)________ ft. _____ msl
   b. Top width (T)________ ft.
   c. Side slope: upstream (S1)________:1
      downstream (S2)________:1
   d. Dimensions of principal spillway __________________________
   e. Dimensions of emergency spillway __________________________
   f. Type and dimensions of control gate __________________________
   g. Type of outlet protection _________________________________
   h. Size of draw down pipe _________________________________

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<tr>
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<th>ELEVATION</th>
<th>RESERVOIR SURFACE AREA (acres)</th>
<th>RESERVOIR CAPACITY (acre-feet)</th>
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<td>TOP OF DAM</td>
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<td>EMERGENCY SPILLWAY</td>
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<td>PRINCIPAL SPILLWAY</td>
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<tr>
<td>DRAWDOWN PIPE</td>
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<tr>
<td>STREAMBED AT DAM</td>
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</tbody>
</table>

* If Reservoir Capacity is 12 1/2 acre feet or greater at top of Dam, a complete set of plans and specifications must be submitted with and made part of this application/notification. The filing of this application/notification and its approval in no way relieves the landowner(s) from any responsibility or liability for damages from the construction, operation or failure of this structure.
C. DIKE:

(1) Is this application/notification for the construction of a ring dike? □ Yes □ No
If so, will the ring dike tie into existing? □ dike □ roadway □ high ground □ other ______________

(2) Purpose: ____________________________________________________________

(3) Area of land to be protected by dike: ______________ Acres

(4) Description of Dike:
   a. Dike length __________ feet
   b. Dike design:
      1. Top width (T) __________ feet
      2. Side slope upstream (S1) _____:1
         downstream (S2) _____:1
      3. Maximum height (H) __________ feet.
         Minimum height __________ feet
      4. Embankment erosion protection___________________________

(5) Will the dike flood or adversely affect adjacent, upstream or downstream land? □ Yes □ No
   If so, have flowage easements been obtained? □ Yes □ No (If flowage easements have been obtained,
   attach copies and describe provisions of easements, and names of grantors)

(6) Is the proposed dike a result of a township-wide, county-wide, or other water management
    plan? □ Yes □ No   If so, please describe on attached sheet.

D. WETLAND RESTORATION:

(1) The proposed wetlands are __________ Temporary __________ Permanent

(2) Drainage area above the structure ______________ Acres

(3) Are the dam/ditch plug and restored wetland entirely on the applicants land? □ Yes □ No
   If not, land rights are needed to construct dam/ditch plug and flood land. Copies of all easement should be included.

(4) Is this project mitigation for another project? □ Yes □ No (If yes, describe project)___________________________

(5) Describe the proposed operation plan for the wetland. ________________________________

(6) If restored wetland volume is less than 12.5 acre-feet at top of structure, provide heights and length of
    structure in feet, surface area in acres, and volume in acre-feet for each restored wetland within each section.

(7) If restored wetland is greater than 12.5 acre-feet at top of structure provide information below for each
    restored wetland and complete Section B.

<table>
<thead>
<tr>
<th></th>
<th>OVERFLOW ELEVATION (feet)</th>
<th>VOLUME (acre-feet)</th>
<th>SURFACE AREA (acres)</th>
</tr>
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<tr>
<td>EXISTING</td>
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<tr>
<td>NATURAL</td>
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<tr>
<td>PROPOSED</td>
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<td></td>
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<tr>
<td>TOP OF STRUCTURE</td>
<td></td>
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</tr>
</tbody>
</table>
E. OTHER WATER RESOURCE FACILITY:
(1) Design Data:
   a. Pond, Lagoon or Dugout
      1. Surface area ________ acres
      2. Maximum storage ________ acre-feet
      3. Maximum depth of water ________ feet
      4. Maximum height of embankment above
         ground ______ feet
   b. Diversion Ditch
      1. Length of ditch ________ feet
      2. Bottom width ________ feet
      3. Side slope ________ feet
      4. Maximum cut ________ feet
      5. Gradient ________ foot/foot

(2) Description of other project, if not a Pond, Lagoon, Dugout, or Diversion ditch:

(3) Waterway into which reservoir would discharge, if drained:

ADDITIONAL INFORMATION AND COMMENTS

_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________

A permit is granted only upon final decision by the state engineer after review by the water resource district in which the dam, dike, or other device is located. The following definitions apply:
1. Waterway: Include any natural or artificial lake, pond, slough, river, stream, brook, coulee, creek, rill, swale, canal, channel, or ditch.
2. Dam: A structure built across a waterway capable of retaining water.
3. Dike: A structure built along or adjacent to a waterway capable of diverting water.
4. Ring Dike: A structure built around an area such as a farm site or village.
5. Other Device: Includes but is not limited to a division ditch, dugout, lagoon, and holding ponds.

If failure of the project will result in substantial damage to property or loss of life the affidavit of Design Engineer Section will need to be completed.

AFFIDAVIT OF DESIGN ENGINEER
I, ____________________________, a registered professional engineer in the State of North Dakota, designed or directly supervised the design of the dam and reservoir as described in this application and on attached sheets, and construction will be approved by me according to the specifications and data shown in this application and data sheets attached hereto. Dated this _______ day of __________ 19____.

The filing of this application/notification in no way relieves the landowner from any responsibility or liability for damages from the construction, operation or failure of the project.

Date Submitted: __________________________ Name (Print or Type): __________________________________________

(Land Owner)

Signed: __________________________ Address: __________________________________________

(Owner of the land on which the project is located or legal entity sponsoring project)

Phone No. (____) - __________________________
Application No._________________

STATE OF NORTH DAKOTA
APPLICATION FOR CONDITIONAL WATER PERMIT

NOTE: Use one application for each type of source (ground water, surface water). Check all appropriate boxes and fill in each blank line. If the question is not applicable to your proposed development, enter NA (not applicable). If more space is necessary, attach additional sheets.

(PLEASE TYPE OR PRINT IN INK)

1. Name of Applicant______________________________________________________________

Mailing Address ___________________________________________________________________

City __________________________ State __________________ Zip ________________________

Home Phone __________________________ Other Phone __________________________

2. Source of water supply:  □ ground water  □ surface water

If surface water:  (a) stream __________________________ a tributary of __________________________

(b) If new impoundment — 1/4 1/4 Sec.____, Twp.____, Rge.____

(c) If existing impoundment, give name __________________________

3. Point of diversion:

(1) 1/4 of Section____ Township____ N., Range____ W.,___________________ County

Additional points of diversion, if any:

(2) 1/4 of Section____ Township____ N., Range____ W.,___________________ County
(3) 1/4 of Section____ Township____ N., Range____ W.,___________________ County
(4) 1/4 of Section____ Township____ N., Range____ W.,___________________ County

4. Amount of water requested:

(a) Annual use from points listed in Item 3 above, rate of diversion, and period of use:

_________________ acre-feet at ___________ cfs gpm from _________ to _________ inclusive

(AMOUNT) (RATE) (MONTH-DAY) (MONTH-DAY)

(b) If impoundment: __________________ acre-feet storage out of which ______________ acre-feet will be used to offset evaporative losses.

(c) Total annual use requested (sum of annual use from 4a and evaporation from 4b):

_________________ acre-feet

5. Proposed construction:

Proposed starting date _______________________________________________________

Anticipated completion date _________________________________________________
6. Description of proposed beneficial water uses:

(a) Irrigation (if applicable)
   
   (1) Method of irrigation: [ ] gravity [ ] sprinkler [ ] waterspreading
   
   (2) Project will involve new irrigated land: [ ] Yes [ ] No
   
   (3) Project will involve supplemental water to existing irrigation: [ ] Yes [ ] No
   
   (4) Description of land to be irrigated (show lot numbers where applicable):

<table>
<thead>
<tr>
<th>SEC.</th>
<th>TWP.</th>
<th>RGE.</th>
<th>NE1/4</th>
<th>NW1/4</th>
<th>SW1/4</th>
<th>SE1/4</th>
<th>NE1/4</th>
<th>NW1/4</th>
<th>SW1/4</th>
<th>SE1/4</th>
<th>TOTAL</th>
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</table>

TOTAL NUMBER OF ACRES TO BE IRRIGATED:

(b) Non-irrigation use (if applicable):

   Municipal ________________________________ Recreation ____________________________
   
   Rural-Domestic __________________________ Fish and Wildlife _______________________
   
   Industrial ______________________________ Other (please specify) __________________

7. Ownership:

   (a) Property owner at the point of diversion: ________________________________
   
   (b) Property owner at the place of use: ________________________________
   
   (c) If either (a) or (b) above are other than the applicant, describe the arrangement enabling the applicant to make this filing:


8. State law requires that cities and landowners within a one-mile radius of the proposed point of diversion be advised of this application. A completed “Notice of Application” will be forwarded to you upon receipt of this application. Therefore, please indicate the number of landowners and cities which you must notify:

9. THE APPLICANT CERTIFIES THAT THE STATEMENTS APPEARING HEREIN ARE TO THE BEST OF HIS KNOWLEDGE TRUE AND CORRECT:

   ___________________________ ___________________________
   (Signature) (Date)
   ___________________________ ___________________________
   (Signature) (Date)
   ___________________________ ___________________________
   (Signature) (Date)

Signature of the applicant(s) must be exactly as in Item 1. If more than one applicant is shown, all must sign.

NOTE: Mail the completed application, along with the required map and application fee to: STATE ENGINEER
State Office Building
900 East Boulevard
Bismarck, ND 58505-0850

SWC FORM NO. 108
Owner/Operator ___________________ Address ___________________
County ________________________ Date __________________

TYPE: Stockwater _____ Irrigation _____ Recreation _____ Fish _____ Wildlife _____
Other (specify) _______________________
(For multipurpose structure, check purposes)

*DRAINAGE AREA: ______ acres. HAZARD CATEGORY ______. DESIGN CLASSIFICATION ______

RESEVOIR AREA
1. Maximum depth = D = ______ ft.
2. Depth over 1000 sq.ft. of area ______ ft.
3. Surface area = SA = ______ ac. (estimated ______ computed ______)
4. Storage capacity in reservoir ______ ac.ft.
   ((1/3 D x SA) or from storage table)

* Category I _____ II _____

PRINCIPAL SPILLWAY
1. Category I: required capacity = drainage area (ac.) x 7 = ______ c.f.s.
2. Category II: peak discharge (Q)* ______ 64Q c.f.s. (required capacity)
3. Type of spillway: hood ______ hood with weir box ______ drop inlet ______
4. Weir length ______ ft. (riser diameter ______ inches)
   (weir box ______ ft. x ______ ft.)
5. Barrel diameter ______ inches; length ______ ft.
6. Hw = ______ ft. Qw = ______ c.f.s.
7. Hor = ______ ft. Qor = ______ c.f.s.
8. HOB = ______ ft. QOB = ______ c.f.s.
9. HB = ______ ft. QB = ______ c.f.s.
10. Principal spillway capacity ______ c.f.s. (must equal or exceed 1 or 2)
    (lesser of 6, 7, 8 or 9)

EMERGENCY SPILLWAY
1. Peak discharge (Q) ______ c.f.s.*
2. Shaped spillway design
   a. Depth of water above ES crest Hp = ______ ft.
   b. Total length of spillway L = ______ ft.
   c. Length of level section ______ ft.
   d. S0 = ______
   e. Discharge per foot of width** q = ______ c.f.s.
   f. Design width W=Q/q = ______ ft.
   g. SS = ______ : 1
3. Natural spillway design
   a. Top width of spillway at design flow depth ______ ft.
   b. Cross sectional area at flow depth ______ sq.ft.
   c. Mean depth = cross sectional area top width = ______ ft.
   d. S0 = ______
   e. Crest length (approx. level section) ______ ft.
   f. Design capacity (Q)* ______ c.f.s.

* THIS FORM WAS MODIFIED BY THE AUTHORS OF THIS HANDBOOK
SECTION Q DROP INLET

Inlet protection
Q (Max.) = ___ c.f.s.
Std. Dwg. No. ______

DATE: 5/83
FILE: 210-11

Rig ht. of dam at deepest section
Top of dam, El. ______
Emergency spillway, El. ______
Pipe inlet El. ______

Original ground
(Variant)

% gr. 1:1

B = "'
Saturated zone = B + 1/2 = "'

--- x --- go. C.M. or
--- x --- concrete anti-seep collars. req'd @ " c-c

F.L. El. ______

E l. ______

Bend 1:1.0
Core trench ?

--- L = "'

% gr. 1:1

--- Pipe dia. go. ______

--- Emerg. spillway El. ______

--- Metal plate go. welded to pipe

--- 12" thick

--- h

--- Pipe dia. go. ______

--- L = " in.

--- W = " in.

--- A = " deg.

SUPPORT

EMERGENCY SPILLWAY

For detail of concrete slab at inlet, see drawing 5.L-12,040

Compiled ___________________________ Date __________

Checked ___________________________

Drawing No. _________________________

PLAN FOR: HOOD INLET STRUCTURE

LOCATION: MAP & PLAN OF DAM & SPILLWAY
TABLE OF QUANTITIES

<table>
<thead>
<tr>
<th>ITEM</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embankment (attach computation sheets)</td>
<td>Cu.Yd.</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>Excavation (attach computation sheets)</td>
<td>Cu.Yd.</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>______ pipe; dia. ______ in.</td>
<td>Lin.ft.</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>______ pipe; dia. ______ in.</td>
<td>Lin.ft.</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>______ ft. x ______ ft. antiseep collars ______ ga.</td>
<td>Each</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>______ type trash rack</td>
<td>Each</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>Elbow ______ degrees (where required)</td>
<td>Cu.Yd.</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>Concrete (class ______)</td>
<td>Cu.Yd.</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>Reinforcing steel</td>
<td>Lb.</td>
<td>__________</td>
<td>__________</td>
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<tr>
<td>Valve: type ______ size ______</td>
<td>Each</td>
<td>__________</td>
<td>__________</td>
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<tr>
<td>Fencing: type ______</td>
<td>Each</td>
<td>__________</td>
<td>__________</td>
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<tr>
<td>Riser and stub (see detail)</td>
<td>Each</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>Riprap</td>
<td>Cu.Yd.</td>
<td>__________</td>
<td>__________</td>
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<tr>
<td>Other (specify)</td>
<td></td>
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</tbody>
</table>

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APPENDIX C

1. USDA-Soil Conservation Service “Job Diary”

JOB DIARY

Book No. ___

(Site number or Project)

(Subwatershed)

(Watershed)

Contract No. _______________________

Date of contract ____________________

Contractor __________________________

Date work started ____________________

Date work completed __________________

Landowner(s) _________________________

INSTRUCTIONS

The JOB DIARY is the pertinent history of the project beginning with the showing of the site to prospective bidders and concluding with the completion of the job. Keep the diary at hand at all times; make complete, legible entries as events occur and sign them.

Pages are provided in the front of the diary for (1) listing the information in the bid schedule, (2) listing the data for material certification and (3) keeping the equipment operating record. Note: To keep the “Type and size of unit” column visible for the pages following it, fold the right-hand sheet back on itself to expose that page in two half-page segments.

Use one numbered page for each shift in which the contractor performs work. Make appropriate entries to record weather, rainfall, duration of work, force used, quantities of work accomplished, and the narrative record. Include in the narrative record, instructions given the contractor, notation of stakes set, measurements taken, tests made, equipment and material delivered to or removed from the site, time lost, cause of delays, rejected work, problems, etc. Show the time of other Service employees on the site and the work they performed. Record the names and purpose of job related visitors. Note pertinent points of discussions between landowners and contractors or their supervisory personnel.

Additional ruled pages are provided in the back for supplemental narrative. Cross-reference the supplemental entries; date and sign them. See Chapter 7 of the Watershed Protection Handbook for more detailed instructions.
## EQUIPMENT OPERATING RECORD (Hours/Day or Shift)

<table>
<thead>
<tr>
<th>EQUIP. NO.</th>
<th>TYPE AND SIZE OF UNIT</th>
<th>REPORT NUMBER</th>
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### Weather
- **Min. Temp.**
- **Max. Temp.**

### Precip.
- **Inches**
- **Storm Period**
- **A.M.**
- **P.M.**

### Shift No.
- **A.M.**
- **P.M. To**
- **P.M.**

### Work Period
- **A.M.**
- **P.M. To**
- **P.M.**

## WORK FORCE
- **Supt.**
- **Skilled**  
- **Labor**

## Foreman

### ESTIMATED QUANTITIES OF PAY WORK ACCOMPLISHED

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>ITEM</th>
<th>UNIT</th>
<th>QUANTITY</th>
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</tbody>
</table>

### NARRATIVE

---

Report No. | Date | 19
---|---|---

---
NORTH DAKOTA STATE WATER COMMISSION

Change

Order No.

Contract dated for

To

County

Contractor,

North Dakota

This change is made under the terms of or is supplemental to your present contract and, if and when approved, you are ordered to perform the work in accordance with the additions, changes, or alterations hereinafter described.

EXPLANATION OF CHANGE IN PLAN RECOMMENDED

<table>
<thead>
<tr>
<th>Spec. No.</th>
<th>Item of Work</th>
<th>Unit</th>
<th>Orig.</th>
<th>Prev.</th>
<th>Change Quantity</th>
<th>Revised Quantity</th>
<th>Increase Quantity</th>
<th>Decrease Quantity</th>
<th>Unit Price</th>
<th>Increase Amount</th>
<th>Decrease Amount</th>
</tr>
</thead>
</table>

Note—Quantities shown are not necessarily pay quantities and are subject to change.

This order — Total Increase $     Total decrease $     Net increase or decrease $

Total Original Contract Amt. $     Total increase or decrease to date $

I hereby accept this order both as to work to be performed and prices on which payment shall be based.

For Contractor

Other Parties to Contract:

APPROVED

(Signature) (Title)

(Signature) (Title)

Date

Construction Engineer

Design Division

APPROVED

Chief Engineer

Date

CHANGE ORDER

SWC Form #194 DIST: CONTRACTOR, OTHERS, CONST ENGR., ACCT., FILE 500-6-72 61
APPENDIX D

Dam Inspection Checklist
INSPECTION CHECKLIST

NAME OF DAM: 
COUNTY: 
OWNER: 
INVENTORY NO.: 
HAZARD CATEGORY: 
TYPE OF DAM: 

DATE INSPECTED: 
WEATHER: 
TEMPERATURE: 
POOL ELEVATION: 
TAILWATER ELEVATION: 
STAGE 1 CREST ELEVATION: 

DIRECTIONS: MARK AN "X" IN THE YES OR NO COLUMN. IF AN ITEM DOES NOT APPLY, WRITE "NA" IN THE REMARKS COLUMN.

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<th>ITEM</th>
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<td><strong>EMBANKMENT</strong></td>
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</tr>
<tr>
<td>1. UPSTREAM SLOPE</td>
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<tr>
<td>A. Deficient grass cover</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>B. Any erosion or slides</td>
<td></td>
<td></td>
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<tr>
<td>C. Are trees growing on slope</td>
<td></td>
<td></td>
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<tr>
<td>D. Longitudinal cracks</td>
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<tr>
<td>E. Transverse cracks</td>
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<tr>
<td>F. Deficient riprap protection</td>
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<tr>
<td>G. Any stone deterioration</td>
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<td></td>
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<tr>
<td>H. Visual depressions or bulges</td>
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<tr>
<td>I. Visual settlements</td>
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<tr>
<td>J. Burrows</td>
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<td>2. CREST</td>
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<td>B. Misalignment</td>
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<tr>
<td>C. Cracking</td>
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<tr>
<td>D. Are trees growing on crest</td>
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<td>3. DOWNSTREAM SLOPE</td>
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<td>A. Deficient grass cover</td>
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<td>B. Any erosion or slides</td>
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<td>C. Are trees growing on slope</td>
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<td>E. Transverse cracks</td>
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<td>F. Visual depressions or bulges</td>
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<td>A. Is the toe drain flowing</td>
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<td>B. Are the relief wells flowing</td>
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<td>C. Are boils present</td>
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<td>D. Is seepage present</td>
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<td>5. ABUTMENTS</td>
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<tr>
<td>A. Any erosion</td>
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<tr>
<td>B. Visual differential movement</td>
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<tr>
<td>C. Any cracks noted</td>
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<td>D. Is seepage present</td>
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<tr>
<td>E. Any slides</td>
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<tr>
<td>RESERVOIR AREA</td>
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<tr>
<td>1. Slides in reservoir area</td>
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<td>2. Debris producing areas in watershed</td>
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<td>3. Sediment producing areas in watershed</td>
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<td>4. Depressions, sinkholes or vortices in reservoir area</td>
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<td>5. Low ridges/saddles allowing overflow from reservoir</td>
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<td>6. Structures below elevation of maximum surcharge storage</td>
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<tr>
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<td>SPILLWAY</td>
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<td>1. APPROACH CHANNEL</td>
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<tr>
<td>A. Eroding or backcutting</td>
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<tr>
<td>B. Sloughing</td>
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<tr>
<td>C. Restricted by vegetation</td>
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<td>D. Obstructed with debris</td>
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<td>E. Silted in</td>
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<td>2. CONTROL STRUCTURE</td>
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<td>A. Does concrete show:</td>
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<td>1. Spalling</td>
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<td>2. Cracking</td>
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<td>3. Erosion</td>
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<td>4. Scaling</td>
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<td>5. Exposed reinforcement</td>
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<td>B. Do joints show:</td>
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<tr>
<td>1. Displacement or offset</td>
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<td>2. Loss of joint material</td>
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<tr>
<td>3. Leakage</td>
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<tr>
<td>C. If spillway is earth cut</td>
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<tr>
<td>1. Are slopes eroding</td>
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<td>2. Are slopes sloughing</td>
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<td>3. Is crest eroding</td>
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<tr>
<td>D. If controlled spillway</td>
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<tr>
<td>1. Are gates bent/broken</td>
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<td>2. Are they corroded/rusted</td>
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<td>3. Are controls, hoists, etc.</td>
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<tr>
<td>in need of repair</td>
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<td>4. Not maintained</td>
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<td>5. Not Operated Periodically</td>
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<td>6. Date last operated</td>
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<td>7. When closed, do they leak</td>
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<td>E. Is weir in poor condition</td>
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<tr>
<td>F. Where is control structure</td>
<td></td>
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<tr>
<td>ITEM</td>
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<td>3. CONVEYANCE STRUCTURE (SPILLWAY CONT)</td>
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<tr>
<td>A. If structure is concrete</td>
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<td>1. Do concrete surfaces show:</td>
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<td>b. Cracking</td>
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<td>c. Erosion</td>
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<td>d. Scaling</td>
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<tr>
<td>e. Exposed reinforcement</td>
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<td>2. Do joints show:</td>
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<td>a. Displacement or offset</td>
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<td>b. Loss of joint material</td>
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<tr>
<td>c. Leakage</td>
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<tr>
<td>B. For an unlined channel</td>
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<tr>
<td>1. Does channel show erosion</td>
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<tr>
<td>2. Side slopes show sloughing</td>
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<td>3. Is channel poorly protected with vegetation/riprap</td>
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<td>4. TERMINAL STRUCTURE</td>
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<td>A. Do concrete surfaces show:</td>
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<td>2. Cracking</td>
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<td>3. Erosion</td>
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<td>4. Scaling</td>
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<td>5. Exposed reinforcement</td>
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<td>B. Do joints show:</td>
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<td>1. Displacement</td>
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<td>2. Loss of joint material</td>
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<td>3. Leakage</td>
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<tr>
<td>C. Do energy dissipators show:</td>
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<tr>
<td>1. Signs of deterioration</td>
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<tr>
<td>2. Are they covered w/debris</td>
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<td>3. Signs of inadequacy</td>
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<td>5. OUTLET CHANNEL</td>
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<td>A. Is the channel:</td>
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<tr>
<td>1. Eroding or backcutting</td>
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<td>2. Sloughing</td>
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<td>3. Obstructed</td>
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<td>4. Inadequately riprapped</td>
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<td>ITEM</td>
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<tr>
<td><strong>OUTLET WORKS</strong></td>
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<td>1. APPROACH CHANNEL</td>
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<td>A. Eroding or backcutting</td>
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<td>B. Sloughing</td>
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<td>C. Restricted by vegetation</td>
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<td>D. Obstructed with debris</td>
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<td>E. Silted in</td>
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<td>2. INTAKE STRUCTURE</td>
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<td>A. Do concrete surfaces show:</td>
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<td>2. Cracking</td>
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<td>3. Erosion</td>
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<td>4. Scaling</td>
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<td>5. Exposed reinforcement</td>
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<td>B. Do joints show:</td>
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<td>1. Displacement or offset</td>
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<td>2. Loss of joint material</td>
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<td>3. Leakage</td>
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<tr>
<td>C. Metal Appurtenances</td>
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<tr>
<td>1. Corrosion present</td>
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<td>2. Breakage present</td>
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<td>3. Anchor system poorly secured</td>
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<tr>
<td>D. Obstructed by silt &amp; debris</td>
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<td>3. CONVEYANCE STRUCTURE</td>
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<td>A. If structure is concrete</td>
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<td>1. Do concrete surfaces show:</td>
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<td>b. Cracking</td>
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<td>c. Erosion</td>
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<td>d. Scaling</td>
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<td>e. Exposed reinforcement</td>
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<td>2. Do joints show:</td>
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<td>a. Displacement or offset</td>
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<td>b. Loss of joint material</td>
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<tr>
<td>c. Leakage</td>
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<tr>
<td>B. If conduit is metal</td>
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<tr>
<td>1. Is corrosion present</td>
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<tr>
<td>2. Protective coating deficient</td>
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<td>3. Is the conduit misaligned</td>
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<td>ITEM</td>
<td>YES</td>
<td>NO</td>
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<tr>
<td>4. CONTROL STRUCTURE (OUTLET WORKS CONT)</td>
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<tr>
<td>A. Are service gates in need of repair</td>
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<tr>
<td>B. Emergency gates/stop logs in need of repair</td>
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<tr>
<td>C. Are control valves in need of repair</td>
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<tr>
<td>D. Are they bent/broken</td>
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<td>E. Are they corroded/rusted</td>
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<tr>
<td>F. Not maintained</td>
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<tr>
<td>G. Unoperational</td>
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<td>H. When closed, do they leak</td>
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<tr>
<td>I. Date last operated</td>
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<tr>
<td>J. Is cold water return not operational</td>
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<td>K. Is the low level outlet not operational</td>
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<tr>
<td>5. TERMINAL STRUCTURE</td>
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<td>A. Do concrete surfaces show:</td>
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<td>1. Spalling</td>
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<td>2. Cracking</td>
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<td>3. Erosion</td>
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<td>4. Scaling</td>
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<tr>
<td>5. Exposed reinforcement</td>
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<tr>
<td>B. Do joints show:</td>
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<td></td>
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<tr>
<td>1. Displacement</td>
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<tr>
<td>2. Loss of joint material</td>
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<tr>
<td>3. Leakage</td>
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<tr>
<td>C. Do the energy dissipators:</td>
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<tr>
<td>1. Show signs of deterioration</td>
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<tr>
<td>2. Covered with debris</td>
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<td>3. Show signs of inadequacy</td>
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<td>6. OUTLET CHANNEL</td>
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<tr>
<td>A. Is the channel:</td>
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<tr>
<td>1. Eroding or backcutting</td>
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<td>2. Sloughing</td>
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<td>3. Obstructed</td>
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<td>4. Poorly riprapped</td>
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<tr>
<td>ITEM</td>
<td>YES</td>
<td>NO</td>
<td>REMARKS</td>
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<tr>
<td><strong>DOWNSTREAM AREA</strong></td>
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<tr>
<td>1. Bridges or culverts that may</td>
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<tr>
<td>restrict discharge</td>
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<td>2. Other obstructions which interfere</td>
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<tr>
<td>with discharge</td>
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<td>3. Channel headcutting</td>
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<td>4. Downstream floodwalls, levies</td>
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<td>dikes</td>
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<td>5. Reservoir-connected &quot;springs&quot;</td>
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<td>6. Buildings in flood plain</td>
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<td>7. Overnight recreational sites</td>
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<td>8. Public access sites</td>
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<tr>
<td><strong>PROJECT AREA</strong></td>
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<tr>
<td>1. SITE ACCESS</td>
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<tr>
<td>A. Roads to site inadequate</td>
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<tr>
<td>B. Unreliable under all weather conditions</td>
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<tr>
<td>C. Unreliable at all reservoir &amp; river stages</td>
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<tr>
<td><strong>2. SPILLWAY AND OUTLET CONTROL ACCESS</strong></td>
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<tr>
<td>A. Are catwalks, ladders, bridges</td>
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<tr>
<td>insecurely anchored</td>
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<tr>
<td>B. Are they unsafe</td>
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<tr>
<td>C. Are they below elevation of</td>
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<tr>
<td>high water</td>
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<tr>
<td><strong>INSTRUMENTATION</strong></td>
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</tr>
<tr>
<td>1. List type(s) of instrumentation</td>
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<tr>
<td>2. In poor condition</td>
<td></td>
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<tr>
<td>3. Not read periodically</td>
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<tr>
<td>4. Is data unavailable</td>
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<tr>
<td><strong>Notes:</strong></td>
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<tr>
<td>List upstream dams</td>
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<tr>
<td>List downstream dams</td>
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<tr>
<td>List any high water mark</td>
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APPENDIX E

1. Example Categories of Action

2. Emergency Action Plan Directory
EXAMPLE CATEGORIES OF ACTION

CATEGORY I - Failure or Impending Failure Conditions
THE EMERGENCY ACTION PLAN WILL BE ACTIVATED IF ANY OF
THE FOLLOWING CONDITIONS ARE NOTED

1. embankment is overtopped by flood waters;
2. slides on the embankment slopes and a reservoir water level
   near the embankment crest;
3. flows through the embankment, foundation, or abutments;
4. large - cloudy seepage;
5. failure of appurtenant structures such as principal outlet
   works or spillway;
6. mass movement of the dam on its foundation such as spreading
   or mass sliding failure; and
7. severe erosion in the principal spillway area.

CATEGORY II - Potential Failure Conditions
AN IMMEDIATE INSPECTION BY A QUALIFIED ENGINEER IS RE-
QUIRED IF ANY OF THE FOLLOWING CONDITIONS ARE NOTED

1. extremely high water level (a specific level should be deter-
mined for each dam);
2. erosion from wave action caused by high winds;
3. landslide, or slides in the upstream or downstream slopes of
   the embankment;
4. emergency spillway erosion;
5. excessive settlement of embankment;
6. slumping or cracking of dam or abutments;
7. new springs, seeps or boggy areas in the embankment or abut-
ment areas;
8. abnormal instrumentation readings;
9. severe storms; and
10. demonstrations or sabotage.
EMERGENCY ACTION PLAN DIRECTORY *

(Include Items as Appropriate)

OWNERS REPRESENTATIVES RESPONSIBLE FOR PLANNED ACTION & CONTACT LOCATION

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Address</th>
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CITY OF

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COUNTY SHERIFF

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OFFICE OF STATE ENGINEER

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<tbody>
<tr>
<td>Vernon Fahy</td>
<td>State Engineer</td>
<td>900 E. Boulevard</td>
<td>224-2750</td>
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<tr>
<td></td>
<td></td>
<td>Bismarck, ND</td>
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<tr>
<td>Edgar Schmidt</td>
<td>Dam Safety Coordinator</td>
<td>900 E. Boulevard</td>
<td>224-2750</td>
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DIVISION OF EMERGENCY MANAGEMENT

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LOCAL EMERGENCY MANAGEMENT ORGANIZATION

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* For Design Classification III, IV, and V Dams
### AMBULANCE SERVICE

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### HELICOPTER SERVICE

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### DIVING SERVICE

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### OTHER

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### PERSONS DOWNSTREAM AFFECTED BY FLOOD WATERS

<table>
<thead>
<tr>
<th>Name</th>
<th>Address</th>
<th>Phone</th>
<th>No. of Residents</th>
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