CONNECTICUT RIVER BASIN
SPRINGFIELD, NEW HAMPSHIRE

BOG BROOK DAM
NH 00189
NHWRB 220.12

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

NOVEMBER 1978

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**Keywords:**

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Connecticut River Basin
Springfield, New Hampshire
Bog Brook

**Abstract:**

The dam is a 289 ft. long earthfill structure which incorporates 71 ft. of free everfall spillway and two 4 ft. wide sluiceways with stoplogs. It is intermediate in size with a low hazard potential. The dam is in good condition at the present time. Only minor operations and maintenance type procedures are required to correct the deficiencies.
NATIONAL DAM INSPECTION PROGRAM

PHASE I REPORT

Identification No.: NH 00189
NHWRB No.: 220.12
Name of Dam: BOG BROOK DAM
Town: Springfield
County and State: Sullivan County, New Hampshire
Stream: Bog Brook
Date of Inspection: September 20, 1978

BRIEF ASSESSMENT

Bog Brook Dam is a 289 foot long earthfill structure which incorporates 71 feet of free overfall spillway and two 4 foot wide sluiceways with stoplogs. The embankment portions of the dam are approximately 7 feet high and contain a concrete core wall. The gravity concrete spillway and sluiceway section is founded on bedrock and has a maximum height of approximately 13.5 feet. The dam was constructed in 1957 by the New Hampshire Fish and Game Department for wildlife management purposes.

The dam lies on Bog Brook and receives runoff from 12.1 square miles of steeply sloping, heavy forest. The dam’s maximum impoundment of 2500 acre-feet places it in the INTERMEDIATE size category, while the absence of any downstream hazard for a distance of at least 3 miles indicates a LOW hazard potential classification.

Based on the size and hazard potential ratings and in accordance with the Corps’ guidelines, the Test Flood (TF) is in the range of the 100 year flood to one half the Probable Maximum Flood (PMF). An inflow TF of 5000 cfs yields a maximum discharge at the dam of approximately 3100 cfs, which would result in overtopping on the order of 0.5 feet. The maximum discharge capacity of the dam without overtopping is approximately 2840 cfs. Thus, it is recommended that further hydrologic studies of the spillway adequacy be made.

The dam is in GOOD condition at the present time. Only minor operations and maintenance type procedures are required to correct the deficiencies noted.
Included in these tasks are monitoring of a wet spot on the toe of the embankment, increased brush clearing and the repair of rodent holes, repair of some eroded concrete joints, removal of debris and overhanging trees from the downstream channel, removal of debris and sediment from behind the dam, installation of a gage and the provision of a device for securing stoplogs in place.

The above recommendations and remedial measures should be implemented within two years of receipt of this report by the owner. Based on the dam's GOOD condition, periodic technical inspections should be scheduled every two years.

William S. Zorno
New Hampshire Registration 3226

Robert Minutoli
Massachusetts Registration 29165
This Phase I Inspection Report on Bog Brook Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

CHARLES G. TIERSCH
Chairman
Chief, Foundation and Materials Branch
Engineering Division

FRED J. FRANS, Jr., Member
Chief, Design Branch
Engineering Division

SAUL COOPER, Member
Chief, Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division
PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the Test Flood should not be interpreted as necessarily posing a highly inadequate condition. The Test Flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.
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Overview of dam from left abutment

Overview of dam from left spillway endwall
Overview of dam from upstream right side
1.1 General

(a) Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZD) has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed was issued to GZD under a letter of August 22, 1978 from Colonel Ralph T. Garver, Corps of Engineers. Contract No. DACW 33-78-C-0303 has been assigned by the Corps of Engineers for this work.

(b) Purpose

(1) Perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests.

(2) Encourage and prepare the states to initiate quickly effective dam safety programs for non-federal dams.

(3) Update, verify and complete the National Inventory of Dams.

(c) Scope

The program provides for the inspection of non-federal dams in the high hazard potential category based upon location of the dams and those dams in the significant hazard potential category believed to represent an immediate danger based on condition of the dam.
1.2 Description of Project

(a) Location

The Bog Brook Dam is located on George Hill Road at the intersection designated Washburn Corner. This point is 4.2 miles south of the junction of George Hill Road and Route 4A, which, in turn, is 1.5 miles south of Enfield Center on Route 4A and 5.5 miles south of the town of Mascoma at the intersection of Routes 4 and 4A. The portion of the USGS Mascoma, NH quadrangle on page ix shows this locus. Figure 1 of Appendix B presents a site plan developed from the map and the site inspection.

(b) Description of Dam and Appurtenances

This dam is basically a 289 foot long earthfill structure incorporating two 4 foot wide sluiceways with stoplogs and 71 feet of free overfall spillway (Pg. B-3). The embankment portions of the dam, 77 feet long on the right side and 130 feet long on the left side, are approximately 7 feet high and contain a concrete core wall to a height approximately 2 feet above the permanent spillway crest (Pg. B-4).

Beginning at the right side, the concrete portion of the dam consists of a concrete endwall extending up and downstream, a 4 foot wide sluiceway structure with provision for stoplogs and an invert 2 feet below the spillway crest, a 20.5 foot section of gravity concrete spillway, another sluiceway identical to the previous one but with an invert 7.2 feet below the spillway crest, a 50.5 foot section of spillway with a V configuration and an endwall on the left side. The endwalls are approximately 4.3 feet higher than the spillway crest. The entire gravity concrete structure is founded on hard, generally competent schist and has a maximum height of approximately 13.5 feet above the streambed.

(c) Size Classification

The dam's maximum impoundment of 2500 acre-feet falls within the 1000 to 50,000 acre-feet range which defines INTERMEDIATE size category as defined in the "Recommended Guidelines."
(d) **Hazard Potential Classification**

The dam is located in a sparsely populated area and is at least 3 miles upstream of the nearest population center. These facts, when combined with the structure's fairly broad downstream channel, indicate a LOW hazard potential classification.

(e) **Ownership**

The New Hampshire Fish and Game Department (NHFGD), 34 Bridge Street, Concord, New Hampshire owns the dam. The Department's phone number is (603) 271-3421.

(f) **Operator**

The Engineering Section of the NHFGD controls the operation of the dam. Mr. Stephen A. Virgin is the Department's responsible engineer and he can be reached at the phone number given above.

(g) **Purpose of Dam**

The dam was constructed for the purpose of wildlife management.

(h) **Design and Construction History**

Construction of the dam was completed in 1957. The Fish and Game Department designed the dam and constructed it by force account.

(i) **Normal Operational Procedures**

Day to day operation of the dam rests with local conservation officers who adjust the water level as necessary to accomplish wildlife management goals. Operation for any other purpose would be directed by the chief engineer and accomplished by the local conservation officer; no operations of this nature are on record or can be recalled by the Engineering Section.
1.3 Pertinent Data

(a) Drainage Area

The pond impounded by Bog Brook Dam receives runoff from 12.1 square miles of steeply sloping, heavily forested terrain. Bog Brook and several smaller streams carry runoff into the impoundment. There is no development around the shores of the pond.

(b) Discharge at Dam site

(1) Outlet Works

The dam's only outlets are the two 4 foot wide sluiceways. The sluiceway at the right end of the spillway has its invert at El. 1092.7, while the invert of the other sluiceway is at El. 1087.5.

(2) Maximum known flood at dam site

No data on experienced peak flood flows or pond levels are available for this dam.

(3) Spillway capacity at maximum pool elevation:

2110 cfs at El. 1099

(4) Sluiceway capacity at normal pool elevation:

295 cfs at El. 1094.7

(5) Sluiceway capacity at maximum pool elevation:

730 cfs at El. 1099

(6) Total discharge capacity at maximum pool elevation:

2840 cfs at El. 1099

(c) Elevation (feet above MSL based upon New Hampshire Department of Public Works and Highway Bench Mark 4190020 located on crest of dam)

(1) Top of dam: 1099.0 +

(2) Maximum pool: 1099.0 +
(3) Recreational pool: 1094.7 ±
(4) Spillway crest: 1094.7 ±
(5) Streambed at centerline of dam: 1085.5 ±
(6) Maximum tailwater: Unknown

(d) Reservoir
(1) Length of recreational pool: 2 miles ±
(2) Storage - recreational pool: 1000
            maximum pool: 2500 acre-feet ±
(3) Surface area - recreational pool: 330 acres ±

(e) Dam
(1) Type: Earth embankment with concrete gravity spillway
(2) Length: 289 feet
(3) Height: 7 feet ±
(4) Top Width: 8 feet ±
(5) Side slopes - U/S 3:1
            - D/S 2:1
(6) Impervious Core: 1 foot thick concrete core wall from ledge to El. 1096.5
(7) Zoning, cutoff and grout curtain: Unknown

(f) Spillway
(1) Type: Concrete gravity, free overfall
(2) Length of weir: 71 feet
(3) Crest elevation: 1094.7 feet ±
(4) U/S channel: Shallow approach from pond
(5) D/S channel: Broad and rocky

1-5
(g) Regulating outlets

As mentioned previously, the dam's only regulating outlets are the two 4 foot wide sluiceways with manually installed and removed stoplogs. The sluiceway at the right end, which has its invert at El. 1092.7 can accommodate 2 feet of stoplogs. The second sluiceway, with invert at 1087.5, provides for installation of up to 7.2 feet of stoplogs.
SECTION 2 - ENGINEERING DATA

2.1 Engineering Records

The design of this dam is quite simple and incorporates no unusual features. No original design drawings or calculations are available.

2.2 Construction Records

Plans for the construction of the dam are included in Appendix B. Page B-3, which presents a plan of the dam, was altered to reflect the as-built configuration of the structure.

2.3 Operational Records

The owner operates the dam in a manner consistent with its intended purpose and engineering features.

2.4 Evaluation of Data

(a) Availability

The absence of design drawings and calculations is a significant shortcoming, but is somewhat mitigated by the availability of the construction plans. An overall marginal assessment for availability is, therefore, warranted.

(b) Adequacy

The lack of in-depth engineering data does not permit a definitive review. Therefore, the adequacy of the dam cannot be assessed from the standpoint of reviewing design and construction data. This assessment is thus based primarily on the visual inspection, past performance and sound engineering judgement.

(c) Validity

Since the observations of the inspection team generally confirm the information contained in the construction drawings, with modification, a satisfactory evaluation for validity is indicated.
SECTION 3 - VISUAL OBSERVATIONS

3.1 Findings

(a) General

The Bog Brook Dam is in GOOD condition at the present time and requires only minor routine maintenance for continued safe operation.

(b) Dam

(1) Embankment

The dam's embankment is divided into two sections, one 130 feet long and one 77 feet long, by the spillway and sluiceways. Both sections are approximately 7 feet high and tie into high ground on either side of the dam. The internal construction of the embankments is not known, but existing plans do show a concrete core wall on both sides of the spillway from ledge to El. 1096.5. The core walls tie into the spillway endwalls and into naturally rising ground at the dam's abutments.

Inspection of the embankments revealed no evidence of vertical or horizontal movement. No deficiencies were noted at the junctions with the spillway endwalls or with the natural slopes at either side. The embankments are covered with a thick, low brush which appears to have been recently trimmed. There was no evidence of any sloughing, erosion or cracking of the earthfill. Several small rodent holes were noted, however.

There are no obvious signs of active seepage along either of the embankments. However, at a distance of 95 feet from the left spillway endwall, a wet area approximately 10 feet by 20 feet in plan and 3 to 6 inches deep was noted at the toe of the left embankment some 40 feet from the centerline. There was no evidence of flow or of turbidity, although the water was discolored. Based upon the topography of the area, this location could be a natural ponding point for storm runoff. No obvious deficiencies in the earthfill were noted in this area.
(2) **Spillway**

The gravity concrete spillway is founded on bedrock which appears to be a hard, generally competent schist. While there is some nearly vertical jointing in the rock at essentially right angles to the dam centerline, the low head behind the dam indicates that these joints are not a significant concern.

Observations of the spillway crest revealed no evidence of erosion, spalling, cracking or efflorescence of the concrete. Similar observations apply to the two concrete endwalls.

(3) **Sluiceways**

Both sluiceways show evidence of erosion along the construction joints between their side-walls and the buttress supports on the spillway sides of these structures. Efflorescence and fine random cracking is evident along the same joint on the inside face of both sluiceways. Minor erosion was observed on the concrete sill in the sluiceway located at the right spillway endwall. The stoplogs in place in the sluiceways are in good condition.

(c) **Appurtenant Structures**

This dam has no appurtenant structures.

(d) **Reservoir**

Observation of the reservoir shore revealed no evidence of movement or other instability. A small amount of sedimentation was noted behind the spillway. Examination of the surrounding area revealed no work in progress or recently completed which might increase the flow of sediment into the pond. Additionally, there were no changes to the surrounding watershed which might adversely affect the runoff characteristics of the basin.

(e) **Downstream Channel**

The immediately downstream channel is very rocky and has many overhanging trees.
Some trees are also growing in the channel itself. Additionally, there is a large, corrugated metal arch culvert under the road some 100 feet downstream of the dam which could create a hydraulic constriction in the event of the Test Flood. Since the dam has only limited operational features, these obstructions do not limit the operation of the dam. They could, however, create flow restrictions at a time when such a situation is least tolerable.

3.2 Evaluation

Because most of the dam's key features are readily accessible for observation, the visual inspection provided a satisfactory basis upon which to assign a GOOD evaluation for the majority of those items which affect the safety of the structure.
SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

Based upon information provided by Mr. Virgin of the Fish and Game Department, the water level in the reservoir does not vary much during the year and little manipulation of stoplogs has been necessary for as long as he can remember. Local conservation officers could make adjustments if their periodic inspections deemed such action necessary.

4.2 Maintenance of Dam

The local conservation officers visit the site periodically and report any observed deficiencies back to the Department. Additionally, an engineer from the Department inspects the dam semiannually and upon notification of a problem by the local conservation officers. The engineer then initiates any necessary maintenance activity.

4.3 Maintenance of Operating Facilities

The stoplogs require no maintenance other than periodic inspection and replacement, if necessary.

4.4 Description of Any Warning System in Effect

There is no warning system in effect for this dam.

4.5 Evaluation

The established operational procedures are adequate for Bog Brook Dam. The good condition of the dam reflects well on the Department's maintenance program. Due to the absence of nearby downstream development, the lack of a formal warning system is not a significant concern.
SECTION 5 - HYDROLOGY/HYDRAULICS

5.1 Evaluation of Features

(a) Design Data

The only data sources available for Bog Brook Dam are two construction drawings dated January 1956 and some associated hydraulic calculations. These data have been checked and updated by information acquired in the field. Changes to the original design include the addition of a 4 foot wide stoplog weir on the right end of the spillway and a change in the configuration of the left portion of the spillway. The original spillway capacity calculations are only of value as an approximate check of present calculations, since the dam as actually built differs appreciably from the original design.

(b) Experience Data

No data on experienced peak flood flows or lake levels is available for Bog Brook Pond.

(c) Visual Observations

Bog Brook Dam is an earth embankment and core wall structure built on ledge and with concrete gravity outlet works. The dam has an overall crest length of about 289 feet at El. 1099. The top width of the dam averages 8 feet with two to one and three to one slopes on the embankments.

The dam's control features consist of a 71 foot long broad-crested spillway at elevation 1094.7 and two adjustable four-foot long stoplog weirs. One of the weirs has a permanent concrete base 2.0 feet below the spillway crest, while the permanent base of the other is 7.2 feet below the spillway. At the time of the inspection, both stoplog weirs were set at the same height as the spillway and the pond was at approximately the same level, resulting in only a trickle of flow through the outlet.

Just downstream of the dam is a constricted channel section due to a high roadway embankment with a crest about 2.8 feet higher than the spillway crest. The stream at this location passes through a large 18 foot by 11.5 foot elliptical, corrugated metal culvert. Beyond the culvert, the stream resumes a normal channel and passes through an area having very little, if any, development.

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(d) Overtopping Potential

The hydrologic conditions of interest in this Phase I investigation are those required to assess the overtopping potential of the dam and its ability to safety allow an appropriately large flood to pass. This requires using the discharge and storage characteristics of the structure to evaluate the impact of an appropriately-sized Test Flood.

Guidelines for establishing a recommended Test Flood based on the size and hazard potential classifications of a dam are specified in the "Recommended Guidelines" of the Corps of Engineers. As shown in these Guidelines, the appropriate Test Flood for a dam classified as INTERMEDIATE in size with a LOW hazard potential would be between the 100-year frequency flood and one-half of the Probable Maximum Flood (PMF).

The magnitude of the 100-year peak inflow to Bog Brook Pond is estimated using a regression relationship provided by the USGS in Water Resources Investigations 78-47, "Progress Report on Hydrologic Investigations of Small Drainage Areas in New Hampshire." This equation, which uses the drainage area, main channel slope and the 24-hour, 2-year frequency precipitation to estimate peak inflow, yields a 100-year peak flood flow of 1560 cfs for the Bog Brook Dam basin. A check of the spillway capacity by the New Hampshire Water Resources Board in 1957 derived a 100-year flood flow of 2000 cfs.

The chart of "Maximum Probable Peak Flow Rates" obtained from the Corps of Engineers, New England Division is used to determine the PMF. For the 12.1 square mile drainage area above Bog Brook Dam, which has a hilly topography, the curve for "rolling" terrain gives a PMF flow of 1600 cfs per square mile. This results in a total PMF of 19,400 cfs or a one-half PMF flow of 9,700 cfs.

The "Guidelines" further suggest that if a range of values is indicated for the Test Flood, the magnitude most closely related to the involved risk should be selected. Since the risk is towards the lower end of the LOW category, a Test Flood of 5000 cfs is used as inflow to the Bog Brook impoundment.

The attenuation of the peak, due to storage, is estimated using the procedure suggested by the Corps of Engineers, New England Division for "Estimating the Effect of Surcharge Storage on Maximum Probable Discharges."
The Storage-Stage Curve used for these calculations is developed assuming that the surcharge storage available in a pond is equal to the surface area of the pond times the depth of surcharge. No spreading or increase in surface area with increasing depth is considered. Use of the recommended procedure shows that the pond storage does have a significant attenuating effect on the magnitude of the peak flow, since the calculations result in a corrected Test Flood flow of about 3100 cfs, or a thirty-eight percent reduction in the pond inflow.

The Stage-Discharge Curve is developed by defining discharge as the sum of the flows over the spillway and stoplogs, flow over the dam crest, and the flow over the slopes at the ends of the dam. Since it is possible that stoplogs might not be pulled in the event of the Test Flood, these calculations assume that stoplogs remain in place throughout the flood at spillway level. Thus, the sluiceways are assumed to act as weirs. Paragraph 1.3 presents the discharge capacities assuming that stoplogs were removed.

5.2 Hydrologic/Hydraulic Evaluation

The results of the hydrologic and hydraulic calculations indicate that the outlet capacity of Bog Brook Dam is insufficient to pass the applicable Test Flood of 3100 cfs without overtopping the dam crest. Flow over this portion of the dam is not desirable since the crest is formed by a simple earthen embankment and is not intended to carry flow. Even if it were possible to remove all stoplogs in the event of a major storm, the capacity of the existing outlet works would be only 2800 cfs with the water level at the dam crest. Thus, additional outlet capacity, possibly in the form of an emergency spillway, would be required to safely pass the recommended Test Flood flow.

5.3 Downstream Dam Failure Hazard Estimates

The flood hazards in downstream areas resulting from a failure of Bog Brook Dam are estimated using the procedure suggested in the Corps of Engineers, New England Division's "Rule of Thumb Guidelines for Estimating Downstream Dam Failure Hydrographs." This procedure accounts for the attenuation of dam failure hydrographs in computing flows and flooding depths for downstream reaches.

5-3
For these calculations, failure is assumed to occur as soon as the dam crest is overtopped at a pond elevation of 1099.0 feet. This corresponds to a height of 13.5 feet above the stream bed. If the breach width is assumed to be thirty feet, the resultant peak discharge due to dam failure is 2400 cfs.

Downstream of the dam the stream may be considered in four reaches for these calculations. Below these four reaches is a swamp and pond that would dampen out the effects of any dam failure flows.

The first reach covers the region between the dam and a highway bridge about 100 feet downstream. Due to its short length and well defined channel, this reach passes the peak discharge downstream with no attenuation. At the bottom of this reach, an 18' by 11.5' corrugated metal culvert beneath the roadway controls the discharge passing on to Reach 2.

The flow capacity of the culvert was determined using a nomograph shown in the Handbook of Steel Drainage and Highway Construction Products (American Iron and Steel Institute, 1971). The capacity was computed for a 13.5 foot depth in the reach to be 2200 cfs.

Reach 2 covers a section of stream about 2300 feet long in a well defined channel. This reach would experience a 4.3 foot stage increase while offering little or no attenuation in the peak discharge. The flow passed to Reach 3 is 2190 cfs.

In Reach 3, which covers the next 3500 feet of stream, the channel is wider and flatter than the first reaches, and would develop a flood flow depth of about 5.3 feet. In passing through this reach, the peak flow would be reduced to about 2140 cfs. Reach 4 is a wide, flat swampy area about 8000 feet long that would experience a flow depth of about 5.8 feet, while attenuating the peak flow to about 2000 cfs.

There is no development along any of these four reaches that would be affected by the computed depths of flooding.
6.1 Evaluation of Structural Stability

(a) Visual Observations

The field investigation revealed no significant displacements or distress which warrant the preparation of structural stability calculations based on assumed sectional properties and engineering factors.

(b) Design and Construction Data

While no design drawings or calculations are available, the construction drawings would be of considerable value to a stability analyses were one deemed necessary.

(c) Operating Records

There are no formal operating records for this dam. Thus, no information concerning the stability of the dam during periods of high flow is available.

(d) Post-Construction Changes

There have been no post-construction changes as of the date of this report.

(e) Seismic Stability

The dam is located in Seismic Zone No. 2 and, in accordance with recommended Phase I guidelines, does not warrant seismic analyses.
SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

(a) Condition

The Bog Brook Dam is in GOOD condition at the present time.

(b) Adequacy of Information

The lack of in-depth engineering data does not permit a definitive review. Therefore, the adequacy of the dam cannot be assessed from the standpoint of reviewing design and construction data. This assessment is thus based primarily on the visual inspection, past performance and sound engineering judgement.

(c) Urgency

The remedial measures recommended below should be accomplished within two years of receipt of the Phase I Inspection Report by the owner.

(d) Need for Additional Investigation

No additional investigations are indicated at this time.

7.2 Recommendations

Since the discharge capacity of the dam is insufficient to pass the selected Test Flood, it is therefore recommended that further hydrologic studies of the spillway adequacy be made.

7.3 Remedial Measures

The Bog Brook Dam requires the following operating and maintenance improvements:

(1) Monitor the wet area at the downstream toe of the left embankment to determine the source of the water. If the water is seepage through the embankment, institute appropriate measures to protect the toe of the fill from erosion.
(2) Fill all rodent holes in the embankment.

(3) Conduct a more vigorous program of brush clearing on the embankments, as the vegetation appears to grow rapidly.

(4) Rake out eroded construction joints and pack the joints with high strength mortar.

(5) Remove all debris and sediment from behind the dam.

(6) Clear all vegetation and debris from the downstream channel and trim or remove all trees overhanging the channel.

(7) Install a gage at the dam and institute a program of regularly recorded readings to provide some historical performance data for the dam.

(8) Provide a method of securing stoplogs in place to preclude unauthorized removal.

(9) Perform a technical inspection of the dam every two years.

7.4 Alternatives

There are no viable alternatives to the accomplishment of the following operations and maintenance tasks.
APPENDIX A

VISUAL INSPECTION CHECKLIST

A-1
INSPECTION TEAM ORGANIZATION

Date: September 20, 1978

NH 00189
BOG BROOK DAM
Springfield, New Hampshire
Bog Brook
NHWRB 220.12

Weather: Sunny and warm

INSPECTION TEAM

Robert Minutoli Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZD) Team Captain
William S. Zoino GZD Soils
Nicholas Campagna GZD Soils
Andrew Christo Andrew Christo Engineers (ACE) Structural
Paul Razgha ACE Structural
Richard Laramie Resource Analysis, Inc. Hydrology
<table>
<thead>
<tr>
<th>AREA EVALUATED</th>
<th>BY</th>
<th>CONDITION &amp; REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMBANKMENT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical alignment and movement</td>
<td></td>
<td>No deficiencies noted</td>
</tr>
<tr>
<td>Horizontal alignment and movement</td>
<td></td>
<td>No deficiencies noted; top width variable</td>
</tr>
<tr>
<td>Condition at abutments</td>
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</tr>
<tr>
<td>Trespassing on slopes</td>
<td></td>
<td>No evidence</td>
</tr>
<tr>
<td>Sloughing or erosion of slopes or abutments</td>
<td></td>
<td>None noted; thick, recently trimmed growth over entire embankment; some small rodent holes</td>
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<tr>
<td>Rock slope protection</td>
<td></td>
<td>None</td>
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<tr>
<td>Unusual movement or cracking at or near toe</td>
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<td>None noted</td>
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<tr>
<td>Unusual downstream seepage</td>
<td></td>
<td>Wet area 10' x 20' in plan 95 feet along crest from left spillway endwall and 40 feet downstream of centerline: water is 3-6 inches deep, appears stagnant and shows no evidence of turbidity; no flow noted; based on local topography, could be ponding, area for storm runoff; no other significant observations</td>
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<tr>
<td>Piping or boils</td>
<td></td>
<td>None noted</td>
</tr>
<tr>
<td>Foundation drainage features</td>
<td></td>
<td>Unknown, but none shown on drawings and unlikely</td>
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## CHECK LISTS FOR VISUAL INSPECTION

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<tr>
<td><strong>OUTLET WORKS</strong></td>
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<tr>
<td>a. Approach Channel</td>
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<tr>
<td>Slope conditions</td>
<td>A4</td>
<td>Broad approach from pond with very low banks</td>
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<td>Bottom conditions</td>
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<td>Some siltation behind dam</td>
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<td>Rock slides or falls</td>
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<td>No rock in vicinity</td>
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<tr>
<td>Log boom</td>
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<td>Control of debris</td>
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<td>Small amount of debris submerged behind dam</td>
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<td>None</td>
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<tr>
<td>channel</td>
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<tr>
<td>b. Spillway</td>
<td></td>
<td></td>
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<tr>
<td>Condition of concrete</td>
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<tr>
<td>General condition</td>
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<tr>
<td>Erosion or cavitation</td>
<td></td>
<td>None noted</td>
</tr>
<tr>
<td>Spalling</td>
<td></td>
<td>None noted</td>
</tr>
<tr>
<td>Cracking</td>
<td></td>
<td>None noted</td>
</tr>
<tr>
<td>Condition of joints</td>
<td></td>
<td>No deficiencies noted</td>
</tr>
<tr>
<td>Rusting or staining</td>
<td></td>
<td>None noted</td>
</tr>
<tr>
<td>Visible reinforcing</td>
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<td>None noted</td>
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<tr>
<td>Scaling or efflorescence</td>
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<td>None noted</td>
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A-4
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<tr>
<td>Foundation conditions</td>
<td></td>
<td>Spillway founded on bedrock which appears to be hard, generally competent schist; near vertical jointing at right angles to centerline of dam</td>
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<tr>
<td>c. Sluiceways</td>
<td></td>
<td></td>
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<tr>
<td>Condition of concrete</td>
<td></td>
<td></td>
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<tr>
<td>General condition</td>
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<td>Good</td>
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<tr>
<td>Erosion or cavitation</td>
<td></td>
<td>Some erosion of construction joints between sidewalls and buttress supports on the spillway sides of the sluiceways; minor erosion on concrete sill in sluiceway adjacent to right abutment</td>
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<tr>
<td>Spalling</td>
<td></td>
<td>None noted</td>
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<tr>
<td>Cracking</td>
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<td>Fine random cracking along the construction joints mentioned above on the inside face of both sluiceways</td>
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<tr>
<td>Condition of joints</td>
<td></td>
<td>Good except as mentioned above</td>
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<tr>
<td>Rusting or staining</td>
<td></td>
<td>None noted</td>
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<tr>
<td>Visible reinforcing</td>
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<td>None noted</td>
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<tr>
<td>Seepage or efflorescence</td>
<td></td>
<td>Some efflorescence along construction joints mentioned above</td>
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<tr>
<td>Condition of stoplogs</td>
<td></td>
<td>Good</td>
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<td>AREA EVALUATED</td>
<td>BY</td>
<td>CONDITION &amp; REMARKS</td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>----</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>Adequately secured (tamperproof)</td>
<td></td>
<td>Stoplogs not locked in place</td>
</tr>
<tr>
<td>d. Spillway Endwalls</td>
<td></td>
<td></td>
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<tr>
<td>Condition of concrete</td>
<td></td>
<td></td>
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<tr>
<td>General condition</td>
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<td>Good</td>
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<tr>
<td>Erosion or cavitation</td>
<td></td>
<td>None noted</td>
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<tr>
<td>Spalling</td>
<td></td>
<td>None noted</td>
</tr>
<tr>
<td>Cracking</td>
<td></td>
<td>None noted</td>
</tr>
<tr>
<td>Condition of joints</td>
<td></td>
<td>No deficiencies noted</td>
</tr>
<tr>
<td>Rusting or staining</td>
<td></td>
<td>None noted</td>
</tr>
<tr>
<td>Visible reinforcing</td>
<td></td>
<td>None noted</td>
</tr>
<tr>
<td>Seepage or efflorescence</td>
<td></td>
<td>None noted</td>
</tr>
<tr>
<td>d. Outlet Channel (immediate area)</td>
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</tr>
<tr>
<td>Slope conditions</td>
<td></td>
<td>Downstream area generally gently sloping bedrock: low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>banks with heavy overgrowth</td>
</tr>
<tr>
<td>Rockslides or falls</td>
<td></td>
<td>None noted</td>
</tr>
<tr>
<td>Control of debris</td>
<td></td>
<td>Small amount of debris in channel</td>
</tr>
<tr>
<td>Trees overhanging channel</td>
<td></td>
<td>Heavy overgrowth on both sides which does extend over</td>
</tr>
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<td></td>
<td></td>
<td>channel: some small trees growing in channel</td>
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A-6
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<tr>
<td>Other obstructions</td>
<td></td>
<td>Large corrugated metal, multiplate arch under road 100 feet downstream of dam</td>
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<tr>
<td>c. Existence of gages</td>
<td></td>
<td>None at dam</td>
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<tr>
<td>RESERVOIR</td>
<td></td>
<td></td>
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<tr>
<td>a. Shoreline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evidence of slides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential for slides</td>
<td></td>
<td></td>
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<tr>
<td>b. Sedimentation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Upstream hazard areas in the event of backflooding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Changes in nature of watershed (agriculture, logging, construction, etc.)</td>
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<td></td>
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<tr>
<td>DOWNSSTREAM CHANNEL</td>
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<tr>
<td>Restraints on dam operation</td>
<td></td>
<td>None given dam's limited operational capacity</td>
</tr>
<tr>
<td>Potential flooded area</td>
<td></td>
<td>No development within 3 miles of dam</td>
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## Check Lists for Visual Inspection

<table>
<thead>
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<th>Area Evaluated</th>
<th>By</th>
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<tr>
<td><strong>Operation and Maintenance Features</strong></td>
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<td></td>
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<tr>
<td>a. Reservoir regulation plan</td>
<td></td>
<td>Maintain water level for wildlife management; little or no manipulation of stop-logs required</td>
</tr>
<tr>
<td>Normal procedure</td>
<td></td>
<td>No emergency situation ever encountered since construction; local conservation officer could pull logs if necessary</td>
</tr>
<tr>
<td>Emergency procedures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compliance with designated plan</td>
<td></td>
<td>Satisfactory</td>
</tr>
<tr>
<td>b. Maintenance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality</td>
<td></td>
<td>No O &amp; M type deficiencies noted</td>
</tr>
<tr>
<td>Adequacy</td>
<td></td>
<td>Dam inspected semi-annually by engineers; no problems with maintenance evident</td>
</tr>
</tbody>
</table>

A-8
## APPENDIX B

<table>
<thead>
<tr>
<th>FIGURE 1</th>
<th>Site Plan</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plan, elevation and sections of dam</td>
<td>B-2</td>
</tr>
<tr>
<td></td>
<td>Topographic map of dam site</td>
<td>B-3</td>
</tr>
<tr>
<td></td>
<td>List of pertinent records not included and their location</td>
<td>B-4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B-5</td>
</tr>
</tbody>
</table>
SITE PLAN

BOG BROOK DAM  
NEW HAMPSHIRE

FILE NO. 2057
SCALE: NO SCALE
DATE: NOV. 1978

U.S. ARMY ENGINEER DIV NEW ENGLAND
CORPS OF ENGINEERS

GOLDBERG, ZONO, COHN, CLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.
NOTE: DRAWING HAS BEEN MODIFIED. SCALES ARE NOT AS SHOWN.

TYPICAL DRAINAGE TRENCH

Concrete Structure for
Drainage System
Distance: 30' between trenches

SECTION A-A

NOTE
GZD MODIFICATION:
VISUAL INSPECTION

Bog Brook
Washburn GC
Springfield, MA
Fish and Game
State of: New York

B-3
NOTE: DRAWING HAS BEEN REDUCED
SCALES ARE NOT AS SHOWN

NOTE:
OZD MODIFICATIONS BASED ON
VISUAL INSPECTION; NOT TO SCALE.

Bog Brook Dam
Washburn Corner
Springfield, N. M.

Fish and Game Dept.
State of New Hampshire

8-3
NOTE: DRAWING HAS BEEN REDUCED
SCALES ARE NOT AS SHOWN

NOTE:
G2D MODIFICATIONS BASED ON
VISUAL INSPECTION; NOT TO SCALE.

Bog Brook Dam
Washburn Corner
Springfield, N.H.

State of New Hampshire

B-4
The New Hampshire Water Resources Board, 37 Pleasant Street, Concord, New Hampshire has in its files two pages of hydraulic calculations dated September 3, 1957. The Board may be reached at phone number (603) 271-3406.

The New Hampshire Fish and Game Department maintains records concerning the construction of the dam, including the change order directing the angling of the spillway and the additional sluiceway. The Department's address and phone number are presented in subparagraph 1.2(e).
APPENDIX C

SELECTED PHOTOGRAPHS

C-1
1. View of right sluiceway showing bedrock foundation under concrete portions of dam

2. Detail of Photo 1 showing erosion of construction joint between sluiceway sidewall and spillway buttress support
3. View of center sluiceway showing erosion between sluiceway sidewalls and spillway buttress supports

4. View from channel between dam and road showing bridge culvert
APPENDIX D

HYDROLOGIC/HYDRAULIC COMPUTATIONS

D-1
Test Flood equal to 100 yr frequency flood is 1/4 RH.

Using the recurrence equation worked by Dr. L. Blume in ~76 and summarized in Appendix 2, the 100 yr flood

\[ P_{oc} = 0.65 \times 105 - 0.6 = 72 \]

As design area = 72 ft².

15 ft mean storm time = 110 ft²/min.

To find 2-100yr rise, divide 110 by 2 = 55 in.

\[ P_{oc} = 0.65 \times (110)^{1/2} \times (55)^{1/2} \]

\[ = 1500 \text{ cfs} \]

The RHF for this basin (K = 1217; i = 1.1; and in

Temperature) is the WE curve

\[ \text{RHF} = (900 \times 12) / 24 = 4200 \text{ cfs} \]

Since this value is about 1/3 times of the LD heard

choose the last critical value chosen to be:

\[ h = 5000 \text{ cfs} \]
For capacity calculations, h = 0 at the spillway crest.

- Dam length (across spillway) = 2070 ft
- Spillway height = present = 7110 ft
- Spillway height = total = 7710 ft

D-4
Capacity calculations:

For $h<0$, \[ Q_1 = Q_2 = Q_3 = Q_4 = 0 \]

For $0<h<3$, \[ Q_2 = 3.23 \left( \frac{791}{h} \right) \left( \frac{h}{3} \right)^5 \]
\[ 0 = Q_3 = Q_4 = 0 \]

For $h>3$, \[ Q_3 = 1.31 \left( \frac{791}{h} \right) \left( \frac{h}{3} \right)^5 \]
\[ Q_4 = 2.6 \left( \frac{2070}{h-3} \right) \left( \frac{h-3}{3} \right)^5 \]
\[ 0 = 2.6 \left( \frac{2(h-3)}{(0.5 \times (h-3))} \right) \left( \frac{h-3}{3} \right)^5 \]
\[ 0 = 2.6 \left( \frac{5(h-3)}{(0.5 \times (h-3))} \right) \left( \frac{h-3}{3} \right)^5 \]

The next three pages list the program to compute these equations, its output and a plot of that output.
100 REMARK: DISCHARGE CALCULATION FOR BOG BROOK DAM -
105 REMARK: STOPLOGS TO ELEVATION 1100.0
110 PAGE
120 E=1.5
130 PRINT "DISCHARGE FROM BOG BROOK DAM - STOPLOGS IN PLACE"
140 PRINT USING 150;
150 IMAGE =27*"HEADING"30*T"DISCHARGE"
160 PRINT USING 170;
170 IMAGE "7"*(FEET)"32T"*(CFS)
180 PRINT USING 190;
190 IMAGE 18*T"TOTAL SPILLWAY DAM CREST SIDE SLOPES"
194 PRINT "=
200 REMARK: 04 is flow over one side slope, 03 is flow over the
dam crest, 02 is flow over the sharp crested spillway, and
210 REMARK: 01 is the flow over the other side slope.
220 REMARK: 01 FOR H=0 TO 13 STEP 0.5
230 FOR H=0 TO 13 STEP 0.5
240 O1=3634.8+0E
250 O2=3.33*59.1*0E
260 Q1=0
270 Q4=0
280 Q5=0
290 IF H<0.5 THEN 330
300 Q4=2.08*(S*(H-4.3))*(0.5*(H-4.3))*E
310 O1=2.08*(S*(H-4.3))*(0.5*(H-4.3))*E
310 O4=Q4+Q1
320 O3=2.08*(S*(H-4.3))*E
330 Q5=O2+O3+Q4
340 PRINT USING 350:H, Q5, Q2, Q3, Q4
350 IMAGE 11,20,20,50;100,11D,13D
360 NEXT H
370 END
<table>
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<tr>
<th>HEAD (FEET)</th>
<th>TOTAL (CFS)</th>
<th>SPILLWAY (CFS)</th>
<th>DAM CREST (CFS)</th>
<th>SIDE SLOPES (CFS)</th>
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Storage-Stage Relationship

The surface area of the pond at its normal level is 330 acres and the drainage area from the pond is 12,120 mi². The relationship between storage and stage of the pond is:

1" of runoff yields \( \frac{1\text{ " of runoff}}{250 \text{ acres}} = 0.0246 \text{ " per acre} \).

If 1" of runoff yields 0.0246" increase in water elevation then:

1" rise in water elevation is caused by \( \frac{1\text{ " of runoff}}{2377} = 0.0004 \text{ " of runoff} \).
2. Calculate in flow due to change:

\[ Q = \frac{V}{c} \]

Volume = 6.5"  

\[ c = \sqrt{\frac{2g}{V}} \]

\[ c = \sqrt{\frac{2 \times 32.2}{6.5}} \approx 1.8 \]
Calculation of Estimated Downstream Dam Failure Flood Stages - Based on COE - Rule of Thumb "Guidelines", April 1978.

**Step 1 - Reservoir Storage at Time of Failure**
Assume that the failure occurs at the dam is overtopped (40 ft above the spillway)

\[ \text{Storage} = \text{Normal + Leakage} = 1000 + 230(360) = 2,730,000 \text{ ft}^3 \]

**Step 2 - Peak Failure Outflow**

\[ Q_p = \frac{W_o \sqrt{g}}{n} \left( \frac{Y_o}{Y_0} \right) \]

- \( W_o < 10\% \), width = \( \sqrt{0.1} \) = 30 ft
- \( Y_o = 11 \), water surface = (1010.9 - 1085.9) = 13.5 ft

\[ Q_p = \frac{8.67(30)}{132.2} \left( \frac{30}{13.5} \right)^2 = 2500 \text{ cfs} \]

Use 2500 cfs peak outflow.

**Step 3 - Develop Stage-Discharge Rating for Downstream Reaches**

Assumed cross-sections for the downstream river, based on USGS top and field data, are shown below.

For these calculations, the downstream reach (from the dam) is divided into 4 reaches.

- Reach 1 is 100 feet long and is bordered downstream by a bridge.
- Reach 2 is 2300 feet long with well defined channel between Reach 1 and a base width of 0.03. Reach 2 is a flat, wide, wide reach, about 3500 ft. in height.
- Reach 3 is a flat, wide, unit area over 3000 ft. long and 1000 ft. wide. Both Reach 3 and 4 have an average slope of about 0.005.
Job No. 8553  Day: Seply  RTH  11/4/78  13:06:21

Reach 1  Boy Brook Dam to bridge

- L = 100'
- S = 0.03
- n = 0.04

Reach 2  Bridge to valley

- L = 2500'
- S = 0.03
- n = 0.04

Reach 3  First sample reach

- L = 3500'
- S = 0.005
- n = 0.07

D-14
Job 148  Dan Self
Bou Brook Dam

Reach 4  Swamp

\[ l = 8000' \]
\[ s = 0.005 \]
\[ n = -1 \]

The following sheets contain the capacity estimates for the cross-sections shown above.
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REACHES ONE AND TWO

D-17
Sky 4: Calculate Scour Attenuation

Reach 1  $Q_p = 2500$ cfs  $\Rightarrow h = 9.59$’
$A = V \times 2500$ cfs
$V = \frac{1000 \text{ cfs}}{40000 \text{ ft}^3} = 0.07 \text{ cfs} \times \text{ ft}$
$A = (1 - \frac{h^2}{A})^2$ $\Rightarrow 2500$ cfs  no attenuation

There is no attenuation in this reach by the standard calculations. However, in a real-world situation, the standard method of calculating does not apply. The flow is calculated by the colonel capacity.

To calculate the colonel capacity, the formula from the Handbook of Steel Bridge and Highway Construction Practice (American Iron and Steel Institute, 1971) is used.

The colonel is made of corrugated steel with the required dimensions:

$$A = \frac{b^2}{2}$$

It is assumed that the reach is so short, that the water level at the colonel is equal to the water level above the standard at time of failure, or 18.5 ft. With this depth, the water depth to colonel height ratio is 1:12. Using the monograph, the colonel size and the ratio; the colonel capacity is:

$Q_p = 2000$ cfs
So 2000 cfs is the peak flow in Reach 2

Reach 2  $Q_p = 2000$ cfs  $\Rightarrow h = 3.34’$   
$V = \frac{2000 \times 2500}{7860 \times 2500} = 9.8 \text{ cfs} \times \text{ ft}$
$A = 2000(1 - \frac{3.34}{2500}) = 2191 \text{ cfs}  \Rightarrow 3.34’$
$V = \frac{2000 \times 2500}{7860 \times 2500} = 9.7 \text{ cfs} \times \text{ ft}$
$A = 18.94$
$Q_p = 2000(1 - \frac{3.34}{2500}) = 2191 \text{ cfs}$

D-20
Reach 1:
\[ Q_p = 0.191 \text{ cfs} \]  \[ A_1 = 4.27 \text{ ft}^2 \]  \[ V_1 = \frac{4000 \times 78}{A_1} = 57.7 \text{ cfs} \]
\[ Q_{p1} = 0.191 \times (1 - \frac{1.05}{15}) = 0.184 \text{ cfs} \]  \[ A_2 = \frac{529}{58.6} = 9.5 \text{ ft}^2 \]  \[ V_{p1} = \frac{529 \times 4.5}{58.6} = 57.15 \]
\[ Q_{p2} = 2.191 \times (1 - \frac{5.15}{30}) = 2.138 \text{ cfs} \]

Reach 2:
\[ Q_p = 0.191 \text{ cfs} \]  \[ A_3 = 4.8 \text{ ft}^2 \]  \[ V_3 = \frac{6000 \times 9.1}{4.8} = 175.3 \text{ cfs} \]
\[ Q_{p1} = 0.191 \times (1 - \frac{7.57}{48}) = 0.178 \text{ cfs} \]  \[ A_4 = \frac{9000 \times 4.9}{165.4} = 270.4 \text{ ft}^2 \]  \[ V_{p1} = 170.4 \text{ cfs} \]
\[ Q_{p2} = 2.191 \times (1 - \frac{10.74}{30}) = 2.183 \text{ cfs} \]
APPENDIX E

INFORMATION AS CONTAINED IN

THE NATIONAL INVENTORY OF DAMS
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- REMARKS -

- CONSERVATION -

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