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DEPARTMENT OF THE ARMY

NEW ENGLAND DIVISION, CORPS OF ENGINEERS 424 TRAPELO ROAD WALTHAM, MASSACHUSETTS 02154

REPLY TO ATTENTION OF: NEDED

SEP 29 1979

Honorable Hugh J. Gallen Governor of the State of New Hampshire State House Concord, New Hampshire 03301

Dear Governor Gallen:

I am forwarding to you a copy of the Pierce Power Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Water Resources Board, the cooperating agency for the State of New Hampshire. In addition, a copy of the report has also been furnished the owner, Monadnock Paper Mills, Bennington, New Hampshire 03442.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Water Resources Board for your cooperation in carrying out this program.

Sincerely yours,

Incl As stated MAX B. SCHEIDER Colonel, Corps of Engineers Division Engineer

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NATIONAL DAM INSPECTION PROGRAM PHASE I INSPECTION REPORT

Identification No.: Name of Dam: Town: County and State: Stream or River: Date of Inspection: NH00250 Pierce Power Dam Town of Bennington Hillsborough County, New Hampshire Contoocook River November 20, 1978

BRIEF ASSESSMENT

Pierce Power Dam has a hydraulic height of 28 feet, is of varied width, and is 420 feet long. It is a run-of-the-river, concrete counterfort combined with a concrete gravity dam. The spillway sections are 11 feet high and 168 and 122 feet long respectively, totaling 290 feet; 2-foot flashboards have been installed. It has a leaf sluice and three head gates to control discharge through two turbines installed in the powerhouse. The dam spans a reach of the Contoocook River, and is located in south central New Hampshire. Pierce Power Dam, used for hydropower purposes, has a storage capacity of about 51 acre-feet. The pond is 900 feet in length with a surface area of about 7 acres.

The dam is in poor condition. Major concerns are: a 50-gpm leak and/or seep west of the powerhouse and deteriorated concrete in the dam and appurtenant structures. Minor concern is the failure of the most downstream section of the training wall at the east end of the spillway.

Based on a small size and significant hezard potential classifications in accordance with Corps guidelines, the test flood is 1/4 Probable Maximum Flood (PMF). A test flood outflow of 15,760 cfs (about 83 csm) would overtop the dam by about 0.6 foot (5.1 feet over spillway crest without flashboards). The spillway will pass 10,245 cfs or about 65 percent of the test flood. A major breach at top of dam would probably result in the loss of 3 to 4 lives and appreciable property damage.

The owner, Monadnock Paper Mills, should implement the results of the recommendations and remedial measures given in Sections 7.2 and 7.3 within one year after receipt of this Phase I inspection report; however, seepage monitoring should be implemented promptly.

Warren a. Juman

Warren A. Guinan Project Manager N.H. P.E. 2339

This Phase I Inspection Report on Pierce Power Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the <u>Recommended Guidelines</u> for <u>Safety Inspection of</u> Dame, and with good engineering judgment and practice, and is hereby submitted for approval.

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OOSTPH W. FINEGAN, JR., MEMBER Wayer Control Branch

Engineering Division

CARNEY M. TERZIAN, MEMBER Design Branch Engineering Division

a. Mr Elro

JOSEPH A. MCELROY, CHAIRMAN Chief, NED Materials Testing Lab. Foundations & Materials Branch Engineering Division

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E 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 there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway 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 aide 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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Figure 1 - Overview of Pierce Power Dam.

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NATIONAL DAM INSPECTION PROGRAM PHASE I INSPECTION REPORT PIERCE POWER DAM

SECTION 1 PROJECT INFORMATION

1.1 General

a. <u>Authority</u>. 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. Anderson-Nichols & Company, Inc. 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 were issued to Anderson-Nichols under a letter of November 20, 1978 from Max B. Scheider, Colonel, Corps of Engineers. Contract No. DACW33-79-C-0009 has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) To 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) To encourage and prepare the States to initiate quickly effective dam safety programs for non-Federal dams.

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

1.2 Description of Project

a. Location. Pierce Power Dam is located in the Town of Bennington, New Hampshire and is a run-of-the-river dam spanning the Contoocook River. After discharging over the dam, the Contoocook River flows northerly and then northeasterly for a distance of about 43 miles before becoming confluent with the Merrimack River in Concord, New Hampshire. The Contoocook River is a major tributary in the Merrimack River Basin. Pierce Power Dam is shown on U.S.G.S. Quadrangle, Hillsboro, New Hampshire with coordinates approximately at N 43^o 00' 12", W 71^o 55' 30", Hillsborough County, New Hampshire. (See Location Map Page vii).

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b. Description of Dam and Appurtenances. Pierce Power Dam is a concrete dam about 28 feet high and 420 feet long. The spillway is about 290 feet long and consists of two sections: one section is a counterfort design with an inclined upstream face, about 168 feet long, extending eastward from the west abutment. A 6-foot triangular section about 24 feet long and resting on a concrete block about 26 feet long and 7 feet wide and extending to an unknown depth buttresses the dam at the west abutment. The other section is a conventional gravity section with a vertical downstream face about 122 feet long on a dogleg alignment, and extending from the counterfort section to the abutment wall west of the powerhouse. The east abutment of the dam is comprised of the powerhouse, and three head gates, 9'W x 12'H, located along the upstream side of the powerhouse. The gates are manually operated with control mechanisms located directly above each gate. Adjacent to the west side of the powerhouse is a 3' wide leaf sluice. Upstream of the sluice is a small wooden house that covers a float with electrical wires. (At one time this installation automated the gates.)

c. Size Classification. Small (Hydraulic Height - 28 feet; Storage - 51 acre-feet) based on height and storage (< 40 feet and \geq 50 to < 1000 acre-feet) as given in Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification. Significant hazard. A major breach would probably result in the loss of three to four lives and appreciable property damage. (See Section 5.1 f.)

e. Ownership. The Pierce Power Dam which exists today was built in 1921 by the Monadnock Paper Mills. The ownership has remained unchanged throughout the years. The original dam at this site consisted of an old stone powerhouse and wooden dam which was owned by the Antrim-Bennington Electric Light and Power Company. Monadnock Mills purchased the water rights at the damsite prior to 1921.

f. <u>Operator</u>. The current owner and operator of Pierce Power Dam is Monadnock Paper Mills, Bennington, New Hampshire 03442. Phone: (603) 588-3311.

g. <u>Purpose of Dam</u>. Pierce Power Dam was constructed to provide upstream storage for use in power generation for Monadnock Paper Mills. This purpose continues.

h. Design and Construction History. The original dam at the site consisted of an old stone powerhouse and a wooden dam. No details of this dam were found. In 1921 the existing dam was built. This dam was designed by Aberthaw Construction Company. One drawing prepared by Aberthaw Construction Company, titled "Plan and Sections, Concrete Dam, Monadnock Paper Mills",

dated 7/15/1921 and one untitled and undated preliminary plan were found in the files of the NHWRB. The preliminary plan shows the location of the new concrete dam in relation to an old timber dam, which it replaces and another concrete dam, located upstream, to which it is connected. With this construction two dams are practically combined into one. Inspection discloses that the alignment of the dam as shown on these plans represents the approximate alignment as it exists at the present time with the exception of that portion of the dam just to the west of the powerhouse. The existing alignment of the spillway and training wall at the east spillway abutment as disclosed by visual inspection are shown on the sketch in Appendix B.

i. Normal Operating Procedures. No written operating procedures were disclosed for Pierce Power Dam. The Contoocook River discharge to the damsite is primarily controlled by the Powder Mill Pond Dam, located approximately 5,100 feet upstream. Before reaching the Pierce Power Dam, the discharge from the Powder Mill Pond also flows over the Monadnock Power Station Dam located about 900 feet upstream. Monadnock Paper Mills own and control each of these dams. Generally, they operate the Powder Mill Pond Dam to provide sufficient discharge at the Pierce Power Dam for use in power generation; the power is supplied to their paper processing plant.

It is reported that every July the head gates are opened to release accumulated sediment which has built up behind the dam. This annual opening also permits inspection of the gates and the gate operating facilities.

1.3 Pertinent Data

a. <u>Drainage Area</u>. The drainage area consists of 191 square miles (122,240 acres) of gently rolling terrain.

b. Discharge at Damsite.

(1) Outlet works (conduits) - Three head gates each 9'W x 12'H @ invert elevation 640.6' MSL. Head gate capacities - unknown (controlled by turbines).

(2) The maximum discharge at damsite - A U.S.G.S. gaging station with a drainage area of 368 square miles is located on the Contoocook River near Henniker, New Hampshire. A maximum discharge of 22,200 cfs was reported at this gaging station during the September 1938 flood. Using this figure, the maximum discharge at damsite can be interpolated to be approximately 12,500 cfs.

(3) Ungated spillway (without flashboards) capacity @ top of dam elevation - 10,245 cfs @ 655.9' MSL

(4) Ungated spillway (without flashboards) capacity @ test flood elevation - 12,360 cfs @ 656.5' MSL

(5) Gated spillway capacity @ top of dam elevation - not applicable

(6) Gated spillway capacity @ test flood elevation - not applicable

(7) Total spillway capacity @ test flood elevation - 12,360 cfs @ 656.5' MSL

(8) Total project discharge @ test flood elevation 15,758 cfs @ 656.5' MSL

c. Elevation (ft above MSL).

 (1) Streambed at centerline of dam - 628.1 (at downstream toe of powerhouse); 640.9 (at downstream toe of spillway)

(2) Maximum tailwater - the maximum tailwater during the September 1938 flood is estimated to have been at elevation 637. (See Low Flow and Flood Profile, Page B-11.)

- (3) Upstream invert leaf sluice 653.4Upstream portal invert head gates 640.6
- (4) Recreation pool not applicable
- (5) Full flood control pool not applicable
- (6) Spillway crest 651.4 (without flashboards)

(7) Design surcharge (original design) - unknown (estimated to be 655.9)

- (8) Top of dam 655.9
- (9) Test flood pool 656.5

d. Reservoir (feet)

(1) Length of maximum pool - 900 (to Monadnock Power Station Dam)

(2) Length of pool at spillway crest ~ 900 to Monadnock Power Station Dam)

- (3) Length of flood control pool not applicable
- e. Storage (acre-feet)
 - (1) Recreation pool not applicable
 - (2) Flood control pool not applicable
 - (3) Spillway crest pool 33 (approximate)
 - (4) Top of dam 51 (approximate)
 - (5) Test flood pool 53 (approximate)
- f. Reservoir Surface (acres)
 - (1) Recreation pool not applicable
 - (2) Flood control pool not applicable
 - (3) Spillway crest 7 (approximate)
 - (4) Test flood pool 8 (approximate)
 - (5) Top of dam 7 (approximate)
- g. Dam

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(1) Type - concrete counterfort section combined with gravity section having inclined upstream and vertical downstream spillway faces.

- (2) Length 420'
- (3) Height 30' (structural height)
- (4) Top Width varied

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(5) Side Slopes - vertical downstream; inclined upstream at 1H:1V in part; upstream remainder unknown, though possibly all inclined at 1H:1V.

(6) Zoning - not applicable

(7) Impervious core - not applicable

(8) Cutoff - unknown

(9) Grout curtain - unknown

h. <u>Diversion and Regulating Tunnel</u> - not applicable (See j.)

i. Spillway

(1) Type - concrete counterfort joined with concrete gravity section

(2) Length of weir - 290'

(3) Crest elevation - 651.4' MSL (without flashboards)

(4) Gates - none (has flashboards about 2' high in part)

(5) U/S Channel - The approach channel to the dam consists of the Contoocook River about 150 feet in average width; the channel is open and the banks are tree lined. The State Route 31 highway bridge is located about 450 feet upstream.

(6) D/S Channel - The channel downstream of the spillway consists of large boulders and bedrock and is wide and unobstructed. Downstream of the powerhouse is a narrower tree lined tailrace which joins the main channel about 600 feet downstream of the dam.

j. <u>Regulating Outlets</u>. The powerhouse forms the east abutment of the dam with three 9'W x 12'H headgates at invert elevation 640.6' MSL located along its upstream (south) side. All gates are manually operated with operating mechanisms located directly over each gate.

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SECTION 2 ENGINEERING DATA

2.1 Design

No engineering design data were disclosed for Pierce Power Dam.

2.2 Construction

One drawing prepared by Aberthaw Construction Company, titled "Plan and Sections, Concrete Dam, Monadnock Paper Mills", dated 7/15/1921 and one untitled and undated preliminary plan were found in the files of the NHWRB.

2.3 Operation

No written engineering operational data for the hydropower operations have been prepared. Oral instructions have been in effect during the history of the operations. These instructions are transmitted from supervisors to subordinates.

a. Availability. A search of the files of the New Hampshire Water Resources Board (NHWRB) and direct contact with the owner, revealed only a limited amount of recorded information concerning the above elements.

b. <u>Adequacy</u>. The final assessments and recommendations of this investigation are based primarily on the visual inspection and the hydrologic and hydraulic calculations.

c. Validity. Because of the flow over the dam at the time of the inspection, field measurements could not be taken to validate many reported dimensions and elevations.

SECTION 3 VISUAL INSPECTION

3.1 Findings

a. <u>General</u>. Pierce Power Dam is a run-of-the-river, low concrete dam which impounds a reservoir of small size. At the time of the inspection water was flowing over part of the dam, where the flashboards were either not in place or knocked over; little or no water was flowing over the remainder of the dam where flashboards were in place (See Appendix C, Figure 2.)

b. Dam. Pierce Power Dam is a concrete gravity dam approximately 28 feet high and 420 feet long. It consists of two sections: one section is a counterfort design with an inclined upstream face, about 168 feet long, at the west abutment (See Appendix C - Figure 3); the other section is a conventional gravity section with a vertical downstream face, about 122 feet long on a dogleg alignment, and extending from the counterfort section to the powerhouse on the east abutment. The concrete in the dam is deteriorated and coarse aggregate is exposed on the concrete face. The leading edge of the concrete piers have eroded up to 3 inches. (See Appendix C - Figure 4.) A concrete cap which has been added since the original construction shows placement of the concrete was difficult because of overflow; rags were placed in the forms to preclude washouts. (See Appendix C - Figure 5.)

About 260 feet of the entire length of the dam is an overflow spillway section. Flashboards about 2 feet high are in place along about 200 feet of the spillway section; over the remaining 60 feet of the spillway section the flashboard supports have been bent over to a horizontal position and some of the flashboards are missing entirely. At the time of the inspection, water was flowing over the failed flashboards or where they were missing but not over the upright flashboards. (See Appendix C - Figure 2.)

Bedrock is exposed at the downstream side of the overflow section along its entire length, and it appears that this section of the dam is founded on bedrock. No signs of significant leakage underneath the overflow section of the dam were noted.

Between the end of the overflow section and the powerhouse there is a knob of high ground which separates the main channel from the tailrace. The dam in this section consists of a low structure, having the appearance of a retaining

wall, built against the upstream side of the knob. It could not be determined from the visual inspection whether this wall is founded on soil or bedrock. A large quantity of seepage, approximately 50 gpm, was discharging from the soil and rock adjacent to the west side of the powerhouse structure downstream from this wall (See Appendix C - Figure 6). The discharge water was clean. The elevation at which the water discharged was about 13 feet below reservoir level and 10.5 feet above tailwater level in the tailrace.

At the west end of the dam, there is a concrete training wall which extends upstream and downstream of the dam. A short embankment section from the retaining wall forms the abutment, and a 20-inch wide cutoff wall extends about 25 feet from the training wall through this embankment to the abutment. The abutment itself is soil. No information was disclosed in the available records to indicate whether the cutoff wall is founded on soil or bedrock. No seepage was observed on the downstream side of the abutment.

At the east end of the dam is a powerhouse with retaining walls which retain the earthfill between the powerhouse and the abutment. A substantial amount of efflorescence on the concrete was noted on the downstream side of the powerhouse. (See Appendix C - Figure 7) The abutment itself is soil. There is no information in the available records to indicate whether the powerhouse or the retaining walls are founded on soil or rock. Minor seepage was discharging near the east side of the powerhouse.

c. Appurtenant Structures. Visual inspection of the gate structure on the upstream face of the powerhouse was limited to the visible portion above the water line. The leading edges of the gate intake structure have deteriorated and reinforcing steel is exposed above the water line. (See Appendix C - Figure 8.) Portions of the gate support walls have eroded up to 3 inches. Limited areas of the concrete walkway in front of the trash racks have also eroded, exposing some of the reinforcing steel in the deck. The submerged condition of the gates prevented inspection; however, the gate operating mechanisms were noted to be in good condition. (See Appendix C - Figure 9.)

The downstream face of the powerhouse was observed as having been recently repaired. It was also noted that the minor cracking in the gunite repair was causing efflorescence. (See Appendix C - Figure 7.) Some erosion of the concrete wall of the powerhouse tailrace was also noted.

A concrete training wall holds the west side of the knob of high ground downstream of the crest. The concrete has an eroded face. The downstream end section of the retaining wall has failed and tipped over into the channel. Because this wall is approximately 30 feet downstream of the dam the failed portion does not appear to have affected the integrity of the dam.

The powerhouse contains one 176-kw and one 500-kw capacity generator with vertical axis turbines which were operating and in good condition.

d. <u>Reservoir Area</u>. The reservoir behind Pierce Power Dam extends upstream about 900 feet to the Monadnock Power Station Dam. State Route 31 bridge crosses the reservoir between the two dams (See Appendix C - Figure 10.). The drainage area upstream of the dams is rolling and is generally covered with forest. It was not possible to see beneath the reservoir surface to determine how much silt was accumulated in the reservoir behind the dam.

e. <u>Downstream Channel</u>. The tailrace downstream of the powerhouse is narrow with some small trees up to several inches in diameter overhanding the channel. It joins the main channel about 600 feet downstream of the dam. (See Appendix C - Figure 11.) Tailwater covers the channel bottom, and it was not possible, on the basis of the visual inspection, to determine whether the bottom of the channel was bedrock or soil.

The channel downstream of the overflow section of the dam is wide and unobstructed. The channel bottom is bedrock and is covered with many large boulders. (See Appendix C - Figure 12.)

3.2 Evaluation

Based on the visual inspection, Pierce Power Dam appears to be in poor condition.

A large seepage adjacent to the west side of the powerhouse and a minor seepage adjacent to the east side of the powerhouse could lead to stability problems if not corrected.

The concrete in the dam is badly deteriorated, and coarse aggregate is exposed.

The flashboards are in generally poor condition, some have been bent over to a horizontal position along part of the length of the crest, and some are missing. This condition is normal in the spring. The ice thaw takes out the flashboards annually.

Extensive efflorescence of the concrete was noted on the downstream side of the powerhouse.

The end section of the training wall on the west side of the main downstream channel has been undermined and has tipped over into the channel. The chief plant engineer states that this section was originally built to protect a power pole from high tailwater. Sufficient wall remains, and therefore the wall has not been replaced.

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SECTION 4 OPERATIONAL PROCEDURES

4.1 Procedures

Although no written operational procedures have been developed for Pierce Power Dam, Messrs. Gordon Bishop, Chief Engineer and George Edwards, Maintenance Superintendent, are fully familiar with the operational procedures of their four dams, Powder Mill Pond, Monadnock Power, Pierce Power and Paper Mill, and the appurtenant facilities including the operations for hydropower generation. Mr. Bishop maintains complete records of all maintenance performed including cost records and operates on an annual budget. Each summer maximum releases of water from Powder Mill Dam are made and power is generated for a period such that the Powder Mill Reservoir is drawn down to about two feet below the concrete crest. This provides additional storage enabling the lower three dams to be drawn down. The gates at Powder Mill are then closed and the lower three dams are drained for inspection and repair. These three lower dams are dry for a week to 10 days. This procedure is usually accomplished in July. Accumulated sediment which has built up behind these dams passes downstream through the waste or head gates. At Pierce Power Dam it is through the latter.

4.2 Maintenance of Dam

Monadnock Paper Mills is responsible for the maintenance of Pierce Power Station Dam. Flashboards are repaired or replaced each summer. Inspection and repair to concrete below normal water surface is accomplished during drawdown. No written maintenance program has been prepared. Maintenance is performed as required; larger items are budgeted and scheduled for completion annually.

4.3 Maintenance of Operating Facilities

The annual releasing of sediment through the head gates enables the testing of the operating facilities to ensure they are functional.

4.4 Description of Any Warning System in Effect

A gage is located on the downstream face of the road crossing located approximately 2,200 feet downstream of Paper Mill Dam. During floodflow periods (usually occurring each spring) when the water reaches 3 feet on the downstream tailwater gage (0' at gage=598' MSL) below Paper Mill Dam, a flood watch around the clock is initiated by maintenance personnel. Two men ride up and down the road along the stream to observe conditions. Evacuation of the plant would be ordered when the flood exceeds 7 feet on this gage as the plant is flooded at 8' on the gage.

Maximum power is generated during this flood watch. Maximum tailwater observed in the last twenty years was 7.5 feet. This resulted in water up to but not in the paper mill plant. Records of all past flooding events are maintained. Flood warning and flood emergency procedures have not been written. Coordination of procedures is made through Civil Police and Civil Defense.

4.5 Evaluation

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Reliance on oral instructions for maintenance and operations is not altogether satisfactory. The present operational and maintenance procedures are adequate to ensure that minor problems encountered are remedied within a reasonable amount of time. However, certain major problems require more than the normal operation and maintenance procedures.

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SECTION 5 HYDROLOGIC/HYDRAULIC

5.1 Evaluation of Features

a. <u>General</u>. Pierce Power Dam is a run-of-the-river dam having relatively little surcharge storage and high spillage. It is a concrete dam consisting of counterfort and gravity sections. The reservoir pool extends to the Monadnock Power Station Dam located about 900 feet upstream as the spillway crest elevation (without flashboards) is about 3.5 feet above the downstream toe of the Monadnock Power Station Dam.

b. <u>Design Data</u>. No recorded hydrologic or hydraulic design data were disclosed for Pierce Power Dam.

c. Experience Data. Low flow and flood profiles for the 1936 and 1938 floods are shown on the Contoocook River, New Hampshire, Plan and Profile, Sheet No. 5 of 7, February 1939, Revised February 1951, U.S. Engineer Office, Boston, Massachusetts (See page B-11.)

d. <u>Visual Observations</u>. At the time of inspection, no visual evidence was noted of damage to any portions of the concrete structure caused by excessive discharges.

e. <u>Test Flood Analysis</u>. Pierce Power Dam is classified as being small in size having a hydraulic height of 28 feet and a maximum storage capacity of 51 acre-feet. Using the Recommended Guidelines for Safety Inspection of Dams, the test flood was determined to be 1/4 PMF.

Using the 1/4 PMF, the test flood discharge was determined to be 15,758 cfs. The overtopping analysis indicates that the dam would be overtopped by 0.6 feet (5.1 feet above spillway crest without flashboards) during the test flood. The maximum spillway (without flashboards) capacity at top of dam is 10,245 cfs or 65 percent of the test flood discharge.

f. Dam Failure Analysis. The impact of failure of the dam at normal flow conditions and at top of dam were assessed using the Guidance for Estimating Downstream Dam Failure Hydrographs issued by the Corps of Engineers. The analysis covered the reach extending from the dam to the Paper Mill Dam, a distance of approximately 1,150 feet. It was determined that a breach at top of dam would create the greater downstream impact. A breach at top of dam pool would increase the stage by 2.8 feet above the antecedent discharge stage of 6.2

feet causing appreciable damage to a house-restaurant building and the Paper Mill Dam resulting in the probable loss of 3 to 4 lives.

One should note because of the lack of storage behind the dam, that test flood flows discharging over the dam, assuming the dam did not fail, would have nearly the same effects on the downstream reach as a breach at maximum pool. As a result of the analysis described above, the Pierce Power Dam was classified Significant Hazard.

SECTION 6 STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. <u>Visual Observations</u>. The visual examination indicates the following evidence of potential stability problems:

(1) Large seepage adjacent to the west side of the powerhouse, and minor seepage adjacent to the east side of the powerhouse.

(2) Deterioration of concrete in the dam.

(3) Efflorescence of concrete on the downstream side of the powerhouse.

b. <u>Design and Construction Data</u>. No design and construction data were available.

c. <u>Operating Records</u>. No operating records pertinent to the structural stability of the dam were available.

d. <u>Post-Construction Changes</u>. The downstream wall of the powerhouse and the retaining-wall section of the dam between the powerhouse and the overflow section of the dam have been gunited. A concrete cap has been constructed on the top of the overflow section of the dam.

e. <u>Seismic Stability</u>. The dam is located in Seismic Zone No. 2 and in accordance with recommended Phase I guidelines does not warrant seismic analysis.

SECTION 7 ASSESSMENT, RECOMMENDATION, AND REMEDIAL MEASURES

7.1 Dam Assessment

a. <u>Condition</u>. The visual inspection indicates that Pierce Power Dam is in poor condition at present. The most significant concern with respect to long term integrity of the dam is the large seepage (approximately 50 gpm) adjacent to the west side of the powerhouse.

The source of the leak could not be inspected because of the debris covering that portion of the downstream face. The classification of the dam's condition could be upgraded from poor to fair if the source of the leak could be found and properly repaired. The other major concerns with respect to the long-term integrity of the dam are.

(1) Deterioration of concrete in the dam.

(2) Efflorescence of concrete on the downstream side of the powerhouse.

(3) Small trees overhanging the tailrace.

b. Adequacy of Information. The information available is such that the assessment of the dam must be based primarily on the visual inspection. The results of the visual examination are adequate to make this assessment.

c. <u>Urgency</u>. The recommendations and remedial measures made in 7.2 and 7.3 below should be carried out by the owner within one year after the receipt of this Phase I report.

d. <u>Need for Additional Investigation</u>. The information available from the visual inspection is adequate to identify the potential problems which are listed in 7.1.a above. These problems require the attention of a competent engineer who will have to make additional studies to design or specify remedial measures to rectify the problems. If left unattended, some of the problems could lead to instability of the structure.

7.2 Recommendations

The owner should retain the services of a Registered Professional Engineer to:

(1) Evaluate the seepages next to the powerhouse and to design remedial measures.

(2) Design and specify remedial repairs for the deteriorated concrete in the dam and appurtenant structures.

7.3 Remedial Measures

a. <u>Operating and Maintenance Procedures</u>. The owner should:

(1) Remove debris from the downstream side of the retaining wall section of the dam immediately west of the powerhouse.

(2) Remove trees and brush from the banks of the channels for a distance of 50 feet downstream from the dam.

(3) Inspect the dam and monitor the seepage downstream of the dam once a week. (Initiate monitoring promptly.)

(4) Establish a written surveillance and warning program to follow in the event of emergency conditions.

(5) Engage a Registered Professional Engineer to make a complete technical inspection of the dam and appurtenant structures once every two years.

7.4 Alternatives.

None.

APPENDIX A

VISUAL INSPECTION CHECKLIST

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VISUAL INSPECTION CHECKLIST PARTY ORGANIZATION

PROJECT Pierce Power Dam, N.H.	DATE November 20, 1978
	TIME 11 AM
	WEATHER <u>Clear</u> , cold
	W.S. ELEV. U.S. DN.S.
PARTY:	653.7 628
1. Warren Guinan 6.	Ronald Hirschfeld
2. Robert Langen 7.	Harold Wilcox (1/3/79)
3. Stephen Gilman 8.	John Falcione (1/3/79)
4. Leslie Williams 9.	
5. Robert Ojendyk 10.	
PROJECT FEATURE	INSPECTED BY REMARKS
1. Hydrology/Hydraulics	R. Langen
2. Structural Stability	S. Gilman
3. Soils & Geology	R. Hirschfeld
4. Mechanical	J. Falcione
5. Electrical	H. Wilcox
6	
7	
8	
9	
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PERIODIC INSPECTION CHECKLIST		
PROJECT Pierce Power Dam, N.H.	DATE <u>November 20, 197</u> 9	
PROJECT FEATURE Intake Channel & Structure NAME		
DISCIPLINE NAME		
AREA EVALUATED	CONDITION	
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE		
a. Approach Channel	Contoocook River	
Slope Conditions	Good	
Bottom Conditions	Not visible beneath pond surface	
Rock Slides or Falls	None	
Log Boom	None	
Debris	Little	
Condition of Concrete Lining		
Drains or Weep Holes	None	
b. Intake Structure		
Condition of Concrete	Top of leading edges of piers	
Stop Logs and Slots	are spalled; concrete eroded below.	
	Good; clear of debris	

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DEDICATION CHECKLIST		
PROJECT Pierce Power Dam, N.H.	DATE November 20, 1978_	
PROJECT FEATURE Control Tower	NAME	
	NAME	
DISCIPLINE		
AREA EVALUATED	CONDITION	
OUTLET WORKS - CONTROL TOWER		
a. Concrete and Structural		
General Condition	Good	
Condition of Joints	Good, no apparent movement	
Spalling	1"-3" at leading edges of piers	
Visible Reinforcing	None wall areas recently gunited	
Rusting or Staining of Concrete	None	
Any Seepage or Efflorescence	Little at hairline cracks on down	
Joint Alignment	Good	
Unusual Seepage or Leaks in Gate Chamber	None apparent - not inspected	
Cracks	None	
Rusting or Corrosion of Steel	Very little where embedded in concrete.	
b. Mechanical and Electrical		
Air Vents	The mechanical gates were in	
Float Wells	The wheels for the operating	
Crane Hoist	tacilities have been removed and stored because of vandalism.	
Elevator		
Hydraulic System	1	
Service Gates	1	
Emergency Gates		
Lightning Protection System		
Emergency Power System	1	
Wiring and Lighting System		

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PERIODIC INSPECTION CHECKLIST		
PROJECT Pierce Power Dam, N.H.	DATE <u>November 20, 197</u> 8	
PROJECT FEATURE Outlet Structure	& Channel NAME	
DISCIPLINE	NAME	
AREA EVALUATED	CONDITION	
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL		
General Condition of Concrete	Good	
Rust or Staining		
Spalling	Very little - d/s face of building recently gunited.	
Erosion or Cavitation	Some at water line	
Visible Reinforcing	None	
Any Seepage or Efflorescence	Little at hairline cracks, large	
Condition at Joints	seepage about 13 feet below water surface (est 50 gpm)	
Drain holes	None apparent	
Channel		
Loose Rock or Trees Overhanging Channel	Some trees overhanging channel; boulders in channel	
Condition of Discharge Channel	Good	

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PERIODIC INSP	ECTION CHECKLIST
PROJECT Pierce Power Dam, N.H.	DATE November 20, 1978
PROJECT FEATURE Spillway Weir	NAME
DISCIPLINE	NAME
AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	
General Condition	Good
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	Some trees overhanging channel,
Floor of Approach Channel	Not visible beneath pond surface
b. Weir and Training Walls	
Ceneral Condition of Concrete	Fair - top of weir recently
Rust or Staining	recapped with concrete.
Spalling	Entire d/s face has eroded to a
Any Visible Reinforcing	None
Any Seepage or Effloresœnœ	None
Drain Holes	None
c. Discharge Channel	
General Condition	Good
Loose Rock Overhanging Channel	None, but section of training wall
Trees Overhanging Channel	has overturned (last section) Some trees
Floor of Channel	Bedrock and boulders
Other Obstructions	None

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PERIODIC INSE	PECTION CHECKLIST
PROJECT Pierce Power Dam, N.H.	DATE <u>November 20, 1978</u>
PROJECT FEATURE Service Bridg	e NAME
DISCIPLINE	NAME
AREA EVALUATED	CONDITION
QUTLET WORKS - SERVICE BRIDGE	
a. Super Structure	
Bearings	None
Anchor Bolts	None
Bridge Seat	None
Longitudinal Members	None
Underside of Deck	Not inspected
Secondary Bracing	None
Deck	U/s edge spalled with exposed
Drainage System	None
Railings	None
Expansion Joints	None
Paint	None
b. Abutment & Piers	
General Condition of Concrete	Good
Alignment of Abutment	Good
Approach to Bridge	Not applicable
Condition of Seat & Backwall	Not applicable

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PROJECT Pierce Power Dam PROJECT FEATURE Reservoir	DATE November 20, 1978 NAME R. Langen
AREA EVALUATED	REMARKS
Stability of Shoreline	Good
Changes in Watershed	None
Runoff Potential	5 houses along State Paula 21
Upstream Hazards	approach channel and bridge.
Downstream Hazards Alert Facilities	Paper Mill Dam about 1200 feet and Alberto's Restaurant about 1000 feet downstream.
Hydrometeorological Gages	None
Operational & Maintenance Regulations	None
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APPENDIX B

ENGINEERING DATA

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NEW HAMPSHIRE WATER CONTROL COMMISSION DATA ON DAMS IN NEW HAMPSHIRE

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LOCATION	STATE NO
Town Beanington	County Hillsboro
Stream	
Basin-Primary Marsimack River	Secondary Contoacok . Biver
Local Name Piarca. Poster Jam	4
Coordinates-Lat. 43°	Long
GENERAL DATA	
Drainage area: Controlled Sq. Mi.: Un	controlled
Overall length of dam A3Q ft.: Date of Co	nstruction
Height: Stream bed to highest elevlä	ft.: Max. Structure 10.48.
Cost—Dam	: Reservoir
DESCRIPTION C Type-Earth Concrete-	-Gravity
Waste Gates	
Туре	
Number	ft. high x ft. wide
Elevation Invert	: Total Area
Hoist	
Waste Gates Conduit	
Number Material	s
Size ft.: Length	ft. : Area sq. ft.
Embankment	
Туре	
Height-Max	t.: Min ft.
Top-Width	: Elev ft.
Slopes-Upstream on	: Downstream on
Length-Right of Spillway	: Left of Spillway
Spillway	
Materials of Construction	
Length-Total	., ft.: Net
Height of permanent section-max10.48.	√ ft.: Min ft.
Flashboards-Type	: Height ft.
Elevation-Permanent Crest	: Top of Flashboard
Flood Capacity	:
Abutments	
Materials:	
Freeboard : Max	.ft.: Min ft.
Headworks to Power Devel(See "Data on Pow	ver Development'')
OWNER L'ORAGAOON P. Der Mills-Gau	Ling. & Pratt V
REMARKS	ANGTIM N H

Tabulation By A & R & R & T /JA Date October 13, 1939 7/27/42 в-2

NEW HAMPSHIRE WATER CONTROL COMMISSION ON WATER DOWER DEVELOPMENTS IN NEW HAMPSHIRE

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OCATION	46		•		AT DAM NO	8.04
TownBan	nington	•••••	: Count	yHills	bazo	
Stream	ont.goc.g.	ok River			•••••••••••••••••••••••••••••••••••••••	
Basin-Primary	Ner	rimack.Rive	2I	: Secondary	Contocos	kR1wer
Local Name	Pierce	Porer Dam.	••••••		· · · · · · · · · · · · · · · · · · ·	،
ENERAL DATA	` ``	• • •				
Head-Max		t.: Min	ft.: Ave	••••		ver Mill? ft.
Date of Constru	iction	1921	: Use o	f PoweHydzu	Electric.Po	STRIF.
Pondage		*******	ac. ft.: Storage	• ••••••		ac. fl
ESCRIPTION	• •	3 (m. 1 ³) 1115 - 1117 - 1117 - 1117 1116 - 1117 - 1117 - 1117 - 1117	,	•	• •	(.
Racks				•	-	
Size of Rack	Opening		• • • • • • • • • • • • • • • • • • •	••••	····	· · · ·
Size of Bar.			: Materi	al	•••••••••••••••••	
Area: Gross		*****	Sq. Ft.: Net		•	sq. ft
Head Gates						
Туре					•••••••••••••••••••••••••••••••••••••••	••••••••••••••••••
Number	3	: Size12!	ft. high x	<u>91</u>	•••••••	ít. wide
Elevation of	Invert	10.79	: Total	Area	3.24.1	sq. ft
Hoist					•••••••••••••••••••••••••••••••••••••••	· · · · · · · · · · · · · · · · · · ·
Penstock						
Number			: Material			
Size			: Length		•••••••••••••••••••••••••••••••••••••••	
Turbines						÷
Number		. ?	: Makers			•
Rating HP. p	er unit	1-800. н. р	1	Capacity	800	нр
Max. Demen	t C.F.S., p	er unit		: Total	•••••••••••••••••••	cfs
Drive						
Туре			•••••••			• • • • • • • • • • • • • • • • • • • •
Generator						· .
Number			۰ · · · · · · · · · · · · · · · · · · ·		••••••	·····
Make		nghou se	••••••	,		
Rating KW.,	per unit	1-500KVA -	1-270KVA Tota	Capacity	₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩	K. W
Exciter					·····	
Number		: Ma	ke		·····	
Rating-per u	nit		: Total Capac	ity	····· · · · · · · · · · · · · · · · ·	K. W
UTPUT-KWH	RS					
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Form E80

NEW HAMPSHIRE WATER RESOURCES BOARD

QUESTIONNAIRE

WATER POWERS OF NEW HAMPSHIRE

Monadnock Paper Mills Bennington New Hampshire

Gentlemen:

We maintain in this office a list of the water power installations in New Harrshire. In recent months we have had several inquiries concorning the water power installations in the State and have found that our information is in some cases out of date.

We are, therefore, bringing this information up to date and request your cooperation by filling in the questionmaine below with data of your development, and return it to us in the enclosed stamped envelope.

Very truly yours, ren. Richard S. Holperen Chief Engineer

RSH:GMB Encl.

Dam No. 22.04 : Location: Contoocook River at Bennington

1. Will you please check or correct:

	Our Data	Your Corrections
Drainage Area - Sq.Mi. Head - feet Capacity (Total) Wheel - H.P. Gemerator - K.W.	192 25 1150	2 22 800 M

2. Is the power plant now in operation?

3. If not, is the equipment in operable condition?

4. Is the dam in good repair? (Signed)

B-4

NEW HAMPSHIRE WATER HET WELLES BOARD INVENDORY OF DAMS AND WATER POULE DEVELOPMENTS $\overline{D}\overline{D}\overline{M}$ HALTA Morrinizcie III. 2 4+5 combined 22.04 /1225+3fford PLATE <u>Contoocook</u> TME <u>Bennington</u> CAMER <u>Hause Bowen</u> Monducet Mills <u>192</u>,00565147 EOME NAME OF DEA <u>Pierce Power Dani</u> BJ-07_1921 DEACRIPTION <u>Concrete</u> Gravity POWER AFTER AND

IN THE TOTAL ADDRESSPANTE TO ADDRESS ADDRESSPANTE TO ADDRESSIN AND A CRESS ADDRESSISA - FOR ADDRESSISA - FOR ADDRESSIN AND A CRESS ADDRESSISA - FOR ADDRESSISA - FOR ADDRESSIN AND A CRESSISA - FOR ADDRESSISA - FOR ADDRESSIN AND A CRESSISA - FOR ADDRESSISA - FOR ADDRESSIN A CRESSISA - FOR ADDRESS</td APACINY-ACRE FI. REALINES 4 7 Connal plans Aberthow Const Co., Boston, Mass 10 10 POWER DEVELOPMENT Kn ED J.F.S. HEAD FEET FULL GADE KV. MAKE UNITS MO. HP 2----- 800-24 45 65 1155 Veritial 130 -14 - PSC <u>SON KYA</u> Wistinghoose 2400 V 120A ISDAPH. 2000 KVA 11 2400 V 53A 325RPM 25 1 800? 35 oraid 350? Hydro Electric Power for paper mill USE bethvartical waits. REMARKS Accompanying state copied from Army Engineers fiers wates Primary H 2011 - rime gast Coment dam + perer Apuse creeted 1921 at site of \$4. 45 abaudould but tailrace of \$4 excavated to foot of \$5. Pians by Aberthaw Construction Co. Boston in file. Information from Braid, Chief Engineer. Did not Know Size crimake of water whools. 10/4/37:14 + J.H.S. 1925 PS.C. B-5 PARE

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Data by 0.5.0.5.	Fie Inlin2
Owner	permitter Manapuck There Hill:
River or Stream Contancaal	k.River
Pablie Utility No	Draunge area
Wheel Capacity H. P 130.	(Primary II. P.) (90% time) 90.4
Type of Construction	Concrete
Height 14. ft.	Operating Head
Lougth	ength No. 1
Would Failure of Dam do Harm!	1
Present Candidan Media	

Data by	- L. V.3.	
Owner	nadnock Fa	per Hills
River or Stream.	Contooco	ok River
Public Utility	No	Drawage area
Wheel Capacity I	. P 735	{ Primary II. P. }
Type of Construct	ion Con	crete
Ileight10	ft.	Operating Head
Length 200	ft. Spillway Le	ength (No. 1)150ft. (No. 2)
Would Failure of	Dam do Harm?	1
Present Condition.	Fair	Date 1922
374 L.7/B	Good	-1925

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MEMORALDUM

Accompanied by Commissioner Storrs I locked over the dam of the Moradnock Paper Mills known in the Commission's town dam file as No. 4.

This water privilege was purchased of the Antriz-Bennington Lectric Light & Power Company. The dam was constructed in 22. As constructed, it loes not exactly follow the blue print dated April 29, 1921, and marked preliminary, that was furnished by the Aberthaw Construction Company.

The dam was constructed across the entire width of the Contoocook River in two sections; one on the west bank upstream from the section connected with the power house. The old head gateand the stone wall in which it was placed has been removed. This formerly ran about one-third of the way across the river where it joined a wooden dam. This too has been removed. The new cement section was placed downstream from the old wooden structure.

This dam is now completed.

DW: EVH

J. W. 7.

20.4 -

May 23, 1923

TEMORATIDUL.

On July 28, 1921, I visited Bennington, New Hampshire, at the site of the old electric plant of the Antrim-Bennington Electric Light and Power Company. The old power house, and the wooden part of the dam adjoining the same have been removed. Extensive blasting operations for the new wheel pits have been practically completed. The new dam will set on solid ledge its entire length. Only the removal of some semi-loose ledge at the toe of the dam is necessary before actual construction of the dam can begin. Work is also progressing on the tail race.

DWW+DIOI

July 28, 1921

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TATER CUT	
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 $\bar{\nu}_{\rm Bris}$ on which information is Available in the

Bennington
oť,
Town

ütete Nu.	Luention Streng	Name of Body of Water Created	Owner.	Condition
22.01	Nuneles ök.	Wiltenur ^s Lake	A.J. Plerce	liva Lin
22.02	Contoocook II.	1 mores and and the and	Ronadnock Paper Ellls	Operable
22.03	Contoocask M.		Ronadnock Paper Mills	Operate
5-0-12	Contopeolk H.	, 1 1	🗸 Monadnock Paper Mills	
52.0c	Contorcook A.	1	Menudnuck Paper Mille	Operable
22.07	Neureless Brook	2 1 1	J. U.W	Cperneble:
22.05	Jakes Brook	L 1	Ben.Incton dater Board	Orérabl ^r
50°03	Cold Sprin, Bk.	, ,	Bernin ton water Bound	Opera Dle
2.10	Cold Jpring bk.	l ! !	Benathriton weter Board	Corrable
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CONTOOCOOK RIVER LWAY



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Anderson - I CONCORD	Vichols & Co., Inc. NEW HAMPSHIR	U S. ARMY ENGINEER DIV NEW EVGLAND CORPS OF ENGINEERS WALTHAM, MASS
NATIONAL P	ROGRAM OF I	NSPECTION OF NON-FED. DAMS
	PIERCE F	POWER DAM
CONTOOCO	OK RIVER	NEW HAMPSHIRE
		SCALE NOT TO SCALE
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APPENDIX C

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PHOTOGRAPHS



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Factore b = Fooklet welt adress the specification of the known flatsabulate support to the specific spect.



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Figure 4 - Close-up of the exposed coarse aggregate on one of the counterfort piers.



Figure 5 - View of the concrete cap which has been added since original construction.

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busine 6 + Looking at the seepage discharging from the west side of the powerhouse.



b) cove 2 - Looking it the downstream face of the powerhouse. Note the efflorescence on the concrete.

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Figure 8 - Looking at the deteriorated leading edges of the gate intake structure. Note the exposed reinforcing steel.



Figure 9 - View of the gate mechanisms and trash racks located on the upstream face of the powerhouse.

C-5



Figure 10 - Looking upstream into the reservoir from the dam.

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Figure 11 - Overview which shows the tailrace on the left and the downstream channel on the right.

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Figure 12 - Looking at the downstream channel of the overflow section.

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

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Subject H/H derson-Nichols & Company, Inc. PIERCE POWER DAM Computed _____ JOB NO. 3220-12 3 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 ALE 2 DA = 191 M12 3 SIZE CLASSIFICATION = SMALL 4 HAZARD (LASSIFICATION & SIGNIFICANT 5 INSPECTION FLOOD = - PMF 6 7 8 STED #1 9 10 CALLULATE PMF USING "PRELIMINARY 11 GUIDANCE FOR ESTIMATING MAXIMUM 112 PROBABLE DISCHARGES IN PHASE I 13 DAM SAFETY INVESTIGATIONS, MARCH 14 1978." 15 16 SLOPE OF CONTROCOOK RIVER US OF 17 PIERCE POWER STATION DAM # 17 FT/MIL 18 HOWEVER BECAUSE OF CONSIDERABLE 19 STURAGE QUAILABLE IN U/S LAKES AND 20 PONDS THE MAXIMUM PROBABLE FLOOD 21 DEAL FLOW RATE HAS DEEN SELECTED 22 FOR ELAT AND COASTAL RATHER THAN 23 ROLLING FFERAIN 24 25 " FOR FLAT & CUALTAL - DA F 19 MI 26 PME = 330 (*5/m.) 27 28 USE 1/4 PMF FOR DIERCE POWER STATION DAM 29 30 1- · 330 · 191= 15758 (FS 31 32 PEAK INFLOW = 15758 (FS 33 (= PMF-TESTELOOD) 34 35 36 37 D-2 29

Subject H/H PIERCE DOWAR DAM dessourvichols & Company, Inc. Sheet No. Date ____ Computed _ CB NO. 3220-12 0 1 **2 3 4 5 6** 7 **8 9** 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 E 1 1 DEVELOP A DAM DIJCHARGE RATING CURVE ASSUME: (: 37 (SPILLWAY W/O FLASHPOARDS) 3 GATES CLOSED TABLE S-11 (HINGS BRATER) 4 DA = 191 M12 5 SPILLWAY @ FLEV 651.4 MSL 6 7 STED #29: DETERMINE SURCHARGE HEIGHT TO 3 PASS Qp OF 15758 CFS 9 10 TRIAL #1 @ ELEU 655. 9 MSL (LOW POINT BEFORE 111 OVERTOPPINGS 12 2/2 $\hat{\omega}_{r\omega} = CLH$ 13 1:290 == 3/ 14 = 3.7.290.4.5 H= 655.9- 651.4 15 = 10 2 4 2, 8 CFS : 4.5 FT 16 17 18 TRIAL #2 Q ELEU 658 MIL (TOP OF DAM) 19 20 ASSUME (=2.7 (EMBANKMENT) 21 C= 2.6 (BROAD CARITRO WEA 22 8>2.5') TAOLE 53 23 KING S BRATER 24 $Q_{sw} = 3.7 \cdot 290 \cdot (6580 - 651.4)^4$ 25 = 18193.5 CFS 26 Queine = 2.7 · 2.10 (658-655.9) 42 27 28 + 2.6 45 (658 - 656.4) 3/2 29 = 41.1 + 236 8 = 277 3 CFS 30 31 Q_==18194 + 278=18472 CFS 32 33 34 3E 36 37 D-3 38

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Subject H H S. + No. _____ of ____. Date___ 2: 79 terson-Nichols & Company, Inc. DEFICE POWER URM Computed RTD Checked.... JOB NO. 2220- 2 - 0 1 2 3 4 5 6 7 8 9 10 11 12 15 14 15 16 1° 18 19 20 21 22 23 24 25 26 27 28 29 3 ALE 2 060 MSC ELEU TRIAL #3 3 3/2 Qrw = 3.7 290 (660-651.4) 4 5 = 2706 2 683 6 Qweire = 27. 2 20 (660 - .55. 9) 1 + 2 6 45 (6 . 0 - 6 5 6 4) 2/2 1 8 + 2.6 76 (660-658) 12 9 - 2.7. 2.27 (660-658) 31 10 :11 112 = 2242+ 1992+ 5589+ 106.9 13 = 16,09 2 6 FS 14 Q== =7061 + 1689 = 28750 CFS 15 16 17 18 USE THE ABOUF TRIALS TO ESTABLIN A RATING CURVE FOR PIERCE DOWER STATION 119 20 DAM NIO FLASHBOARDS 21 SURCHARGE MEIGHT (ELEVATION) TO DASY 22 QP. OF 15758 CFS 15 656.5' MISL 23 24 (RIFFR TO RATING CURVE ON PAGE 1.0) 25 -26 PILLWAY CREST = 651.4 MIL 21 28 1. SPICLWAY WILL BE OVERTOPPED OF - 29 APAZOXIMATION 5.1 REET DURING THE TELT FLOOD (1/4 PROBABLE MAXIMUM FLOOD) - 36 3.1 32 33 34 35 36 37 D-4

acerson-Nichols & Company,	Inc. Subject <u>H/H</u>	Sheet No of	
JOB NO. 32 2 0 - 12	PIERCE POWER	Computed <u>RF0</u> Checked	
ÉS 0 1 2 3 4 5 SCALE	6 7 8 9 10 11 12 13 14 15	16 17 18 19 20 21 22 23 24 25 26 27 28	829
3 Asrv 4 5 6 7 8 9 10	ME : Spillwar W/FL GATES (LUSED DA = 191 Mi ^b C = 3.2 (H = 1 FLASHBOARD CRI NORMAL STORE	LASHBOARDS 0 1'-+4') (E,C 5.3, King & Brati- EST @ 657.4 MSL AGE = 33 AC-FT	-)
11 12 13 14 15	#1 @ ELEV 654 Q _{5w} = 3.2·290·0 = 431.3 CFS	- (654-657.4)	
16 17 18 19 20 21	# 2 Q ELEV 656 Qsw = 7.2,290 = 3830.5 C	5 (656- (53.4) FS	
21 22 23 24 25 26	THE ABOVE TRIALS T NG CURVE FOR PIER 10N DAM W/FLAJHG	FO ESTARLISH A REE POWER PONROS	
27 28 29 30 31			
32 33 34 35 36			
37 38	D-	-5	



Subject HH PIERCE Dower DAM Shee: No._____ of _____ Date _____ 2 - 7 9 Computed _____ C able in-Nichols & Company, Inc. .0BNO. 3220-12 : S 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 1 F 11 1 3 4 5 6 USE A TYDICAL CROSS SECTION ALONG THE 7 DOWNSTREAM REACH FROM THE DAM TO 1 8 THE PAREL MILL DAM AND ESTABLISH 9 A DISCHARGE RATING CURVE USING THE 10 FULLOWING MANNINGS & OUATION : 11 $Q = \frac{1.49}{2} \cdot A \cdot R^{2/3} \cdot 5''$ 142 13 14 11 = COMPOSITE h VALUE 15 A = AREA OF SECTION FTL 16 12 : HYDRAULIC RADIUS 17 WP WETTED PERIMETER FT 18 19 S = SLOPE OF REACH 20 27 LENGTH OF REACH = 1150 22 23 ELEU @ D/S TOE = 641' MSL 24 25 ELEU @ END OF REACH + 618 MIL 26 $5 = \frac{641 - 618}{1150} = \frac{23}{1150} = 0.02$ 27 28 29 COMPOSITE n = 0.09 30 31 THE TRIAL COMPUTATIONS BELOW REFER TO 12 THE DIS HAZARD CROSS SECTION THAT IS 33 SHOWN ON PAGE D-10. 34 35 36 37 D-7 38

autor Stant KIERCE FOMER DAM 2 - 7.9 Hoganos - A7 0 Loson-Nichols & Compeny, Inc. JOBNU. 3220-12 ° 0 } 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 14 26 21 22 _3 24 25 26 22 20 20 € | 1 1 2 TRIAL #1 ASSUME STACE Q 2' 3 4 4 . 2 · 2 (150 + 220) = 200 KT2 5 6 NA= 50+55+16=221 FT 7 8 9 $Q_1 = \frac{1.49}{0.09} = 270 \cdot 1.67 = 0.02$ 111 112 = 1219 CFS 13 74 :15 TRIAL #2 ASSUME STAGE @ 4' :16 17 A = 1 . 4 . (150 + 290) = 880 FT. 18 19 WP = (50 + 110 + 30 = 290 FT 20 $R_{1} = \frac{380}{290}$ 21 22 1.49 R80 203 02 23 24 25 = 4314 (1) 26 28 TRIAC #7 ACTUME TALE & 6 29 30 A = 1 6 (150 + 101) 1530 012 1 32 WP= 150 + 165 + 45 = 160 FT 33 $R_3 = \frac{1530}{260} = 425$ 34 35 $Q_{1} = \frac{1.49}{0.9} \cdot 1530 + 25 \cdot 002 = 9249 \ crs$ 36 37 38

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SUBJECT HIH PIERCE POWER DAM Sheer Ivo. ______ of Date _____ 2 = 7 9 Computed _____ P ar Nichols & Company, Inc. MANE 3220-12 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 ÷ TRIAL #4 ASSUME STARE & B' A. = - 8 (-50 + 430) = 2320 FT WP4 = 150 + 220 + 61 = 431 FT $R_4 = \frac{2320}{471} = 538$ 8 Ģ $Q_4 = \frac{149}{1009} 2320 538 \cdot 0.02$ 12 = 16678 CFS 3 1:4 TRIAL #5 Assume STAGE @ 10' ht i 15 $A_{r} = \frac{1}{2} \cdot 10 \cdot (150 + 500) = 3250 FT^{2}$ 4. 18 WP= 150 + 275 + 76 = 501 FT 119 $R_{f} = \frac{3250}{501} = 6.49$ 120 $Q_5 = \frac{1.49}{0.02} \cdot 3250 \cdot 6.49 \cdot 0.02$ 122 123 /4 = 26475 CFS 25 26 2.7 TRIAL #6 Assume STAGE Q 14 28 129 AL = 1 . 14 . (150 + 570) = 5040 FT2 30 31 WP = 150 + 315 + 106 = 511 FT 32 $R_{6} = \frac{5040}{571} = 8.83$ 133 34 $Q_{0} = \frac{149}{109} = 5040 \cdot 8.83 \cdot 0.02$ 35 36 31 = 50412 CFS D-9 38




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Subject H/H Anderson-Nichols & Company, Inc. Sheet No. 0'_____ Date 2-79 Computed R70 PIERCE POWER DAM JOB NO. 3220-12 Chacked SQUARES SQUARES 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 2 2 BREACH ANALYSIS 3 4 TO DETERMINE LOWNSTREAM HAZARD 5 FAILURE OF THE DAM WILL BE CONSIDERED 6 AT TWO DIFFERENT RESERVING POOL 7 ELEVATIONS: I.E (1) NORMAL DIOL 8 ELEVATION AND (2) TOP OR JAM POUL 9 ELEVATION AICKIMUM POOL/LOWEST 10 NON-OVERFLOW DOINT ELEVATION 11 12 DEFERMINE NORMAL FLOW CONDITION 13 FOR IONIODCOOL EIVER, (USING MEAN 14 ANNUAL KLOW) 15 16 REFERENCE WATER RESOURCE DATA 17 FOR NEW HAMPSHIRE 18 AND VERMONT WATER 19 YEAR 1976, U.S. 20 GEOLOGICAL JURVEY 21 WATER - DATA CEPSAT 22 N4- VT - 76-1, AUGUST 23 1977 24 25 AT GAGE STATIONS ON CONTOOLOOW RIVER: 26 27 DA= 68.1 mi IMAF = 144 CFS DR 2. 11 CSM 28 DA= 368 MIZ : MAF = 858 CFS OR 2,37 CIM 29 30 DUF TO UPSTREAM STORAGE IF 31 FOWDER MILL POWD 2.33 CIM 15 32 APPLIED TO DA AT PIERCE 33 Power DAM (DA=191mit) 34 35 : NORMAL FLOW (MAF) = 191.2.37 = 445 (FS 36 37 D-12 38

Subject H/H DIERTE POWER DAM Anderson-Nichols & Company, Inc. Sheet No Date Computed JOB NO. 3220-12 Checked SQUARES 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 0 1 1/4 IN. SCALE 1 2 FROM RATING CORVE FOR DAM 3 WITH FLASHBOALDS (PAGE) DISCHARGE 4 OF 445 CFS COARESDONDS WITH 5 FLEVATION OF 654.0'mil OR 0.6' 6 OVER SPILLWAY WITH FLASH PSARDS 7 $\varphi_{p} = \frac{\vartheta}{27} \cdot w_{b} \cdot \sqrt{9} \cdot \sqrt{9}$ 8 9 OP = DISCHARGE THRU BREACH 10 Wh = REACH WISTH 11 G = 32 2 FT/SEC 12 y = Poor FLED - U/S RIVER BED 13 14 15 (1) NORMAL SOOL ELEVATION 16 = 653.4 + 0.6 = 654.0 m/ 17 18 U/S RIVER BED ASSUMED 70 19 SINVERT (LEVATION OF HEAD GATES 20 = 640.6 MSL 21 22 W1 = 0.4 · 420= 168' 23 24 1 = 654.0 - 640.6 = 13.4' 25 Qp = = = 168 · 32.2 · 13.4 26 27 28 = 13, 855. 5 cfs 29 30 Q = DISCHARGE OVER DAM THAT 31 15 NOT BREACHED 32 $Q_{1} = (LH^{2/2} = 3.2 \cdot (290 - 1.68) \cdot 0.6^{3/2}$ 33 34 35 = 181.4 cfs 36 37

D-13

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Anderson-Nichols & Company, Inc.			Subject H/H			Sheet No of Date 7.9		
	JOB NO. 3220-12			PIERCE M	owere unit		Computed <u>RTO</u> Checked	
SQUARES	0123 E	4 5	6 78	9 10 11 12 1	13 14 15 16 17	18 19 20	21 22 23 24 25 26 27	
	1 2 3		TOTAL	BREACH	Q = Qp,	+ 92		
	4 5	= 13, 855, 5 + 181 4						
	6	= 14,036.9 cfs						
	8							
	9 10	(2)	TOP 0	F DAM ,	POOL ELE	VATION	= 655.9'msl	
	11			W8 =	0,4.420=	168'		
	13	U/S RIVER BED ELEVATION = 640.6msl						
-	14			Y.=	655.9 - 6	4 8.6 =	15.3'	
	16 17		Q	=	8 · 32 2 · /	2/2		
	18 19		ф,	- 11- 0.0	a a cfr			
	20 21			- 16,90	┯ , ┭ ◦ · •	,		
	22		Q_{i}	= (2 H	C = .	3.7 (Spi 1.7	LLWAY W/O LASHBOARDS)	
	23 24			= 3.7 . (290	-168) · (65)	5.9-651	(, 4) ^{2/2}	
	25 26			= 4309.0	o cfs			
	27 28		TOTAL	BERACH	$Q = Q_{p_1} +$	02		
	29 30				= / 6,9 04	.4 + 4	4309.0	
	31				= 21, 21	3.4 cf	С.r.	
	32 33							
	34 35							
	36 37	D-14						
} }:	38							

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Subject <u>H/H</u> Anderson-Nichols & Company, Inc. Sheet No. - 7 9 0' Date____ Computed JOB NO. 3220-12 Checked DUARES 0 1 **2 3 4 5 6 7 8 9** 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 4 | SCALE FOR BREACH @ NORMAL FLOW CONSI- IN. 2 3 TOTAL ERFACE Q (NORMAL) = 14,037 cfs 4 STAGE = 7.4' (REFER TO DIS HATTES 5 2MTING CULUE ON 6 PAGE D-11) 7 ANTECEDENT DISCUARGE ! (WITH FLASHERARY) 8 1: (LH3/2 : 3.2 · 290 · 9.6 9 10 - 431.3 cfs 11 STAGE @ 431 cfs = 1.0' 12 13 : INCREASE IN STAGE = 7.4-1.0 14 - 64' 15 16 . 17 FOR BREACH & TOP OF DAM 18 19 TOTAL BREACH Q (TOP OF DAM)= 21,213 efs 20 STAGE = 9.0' (REFER TO DIS 21 HAZAZJ ZATING 22 CURVE ON PAGE D-11) 23 24 ANTECEDENT DIJEMARGE! 25 Q: (LU2/2 = 3,7 , 290. (655.3 - 651.4) 26 27 = 10,242.8 cfs STAGE B10,243 cfs = 6.2' 28 29 30 : INCREASE IN STREE= 9.0-6.2 31 = 2.8 ' 32 33 34 35 36 • 37 D-15

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APPENDIX E

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INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

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