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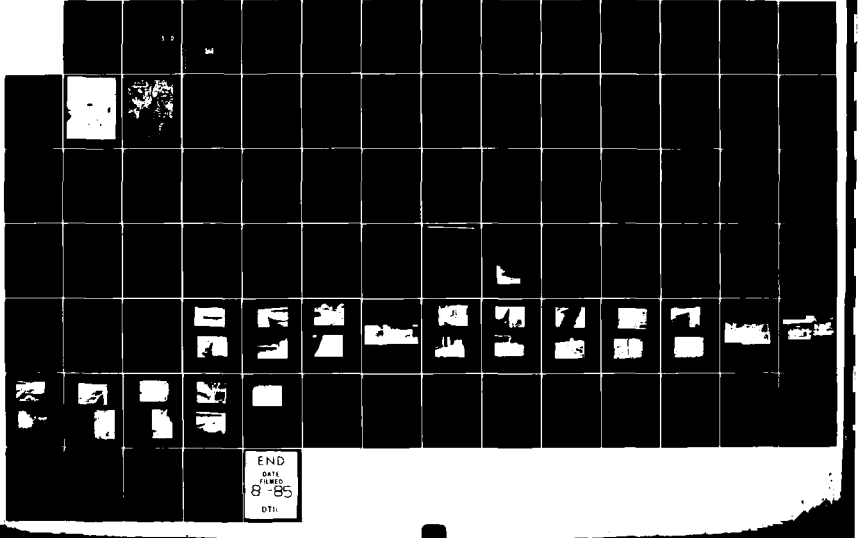

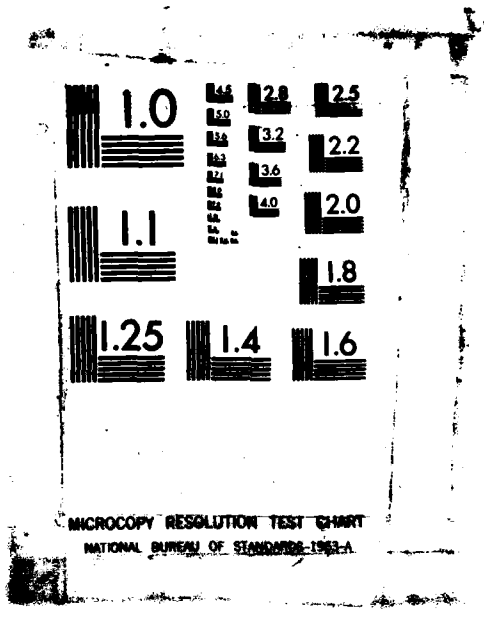
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MERRIMACK RIVER BASIN

MANCHESTER, NEW HAMPSHIRE

KELLEYS FALLS DAM

NH 00299

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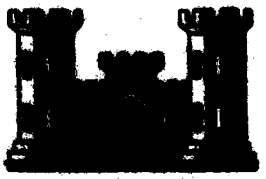
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
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MAY 1978

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19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

DAMS, INSPECTION, DAM SAFETY,

Merrimack River Basin
Manchester, New Hampshire
Piscataquog River

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Tbe dam is a run of the river type dam with an overall length of 503 ft. THe visual inspection of the dam is in poor condition. The dam is intermediate in size with a significant hazard potential. The spillway will pas 38% of the test flood outflow.The owner should remove the flashboards on the dam immediatly.

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KELLEYS FALLS DAM

NH 00299

NHWRB 150.02

MERRIMACK RIVER BASIN
MANCHESTER, NEW HAMPSHIRE

PHASE 1 INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

LETTER OF TRANSMITTAL

FROM THE CORPS OF ENGINEERS TO THE STATE

TO BE SUPPLIED BY THE CORPS OF ENGINEERS

-a-

NATIONAL DAM INSPECTION PROGRAM
PHASE I - INSPECTION REPORT
BRIEF ASSESSMENT

Identification No.: 00299

Name of Dam: Kelleys Falls Dam

Town: Manchester

County and State: Hillsboro, New Hampshire

Stream: Piscataquog River

Date of Inspection: April 24, 1979
May 9, 1979

Kelleys Falls Dam is a "run of the river" type dam, with an overall length of 503 feet. The 192 foot long spillway section is a mass concrete structure. Maximum structural height of the dam is 31 feet. A stone masonry wall 288 feet long follows the left bank upstream of the dam. The left abutment is part of the headworks structure, and the control for the 11 foot diameter gate is located there. The right abutment is constructed of concrete. Engineering data available consisted of three drawings, showing a plan of the spillway and outlet works, and details of the outlet works. No construction data or design calculations were available.

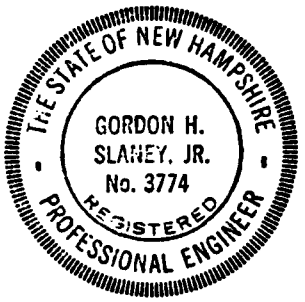
Visual inspection of the dam indicated that the dam is in poor condition. The inspection revealed a number of leaks through the mass concrete spillway section, considerable loss of concrete from the spillway section, seepage around the concrete wall on the right side of the dam, and general deterioration of concrete on the abutments and hydro-building.

Based on the intermediate size of the dam and the significant hazard classification and in accordance with Corps of Engineers guidelines, the test flood is one half the Probable Maximum Flood (PMF) or 55,900 cfs. The one half PMF outflow overtops the dam by 6.8 feet. With the water level at the top of the dam, the spillway will pass 38 percent of the test flood outflow.

See note 8

It is recommended that the owner engage a qualified engineer to make a thorough investigation of the condition of the foundation of the spillway section of the dam, investigate the structural stability of the spillway section of the dam and to investigate the potential for overtopping and ways to increase the spillway capacity. Also, the owner should remove the flashboards on the dam immediately, upon receipt of this report.

The recommendations and remedial measures are described in Section 7 and should be addressed within one year, unless otherwise noted, after receipt of this Phase 1 - Inspection Report by the owner.



Gordon H. Slaney Jr.

Gordon H. Slaney, Jr., P.E.
Project Engineer

Howard, Needles, Tammen & Bergendoff
Boston, Massachusetts

Additional keynote:
Merrimack River Basin;
Manchester, New Hampshire

This Phase I Inspection Report on 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. RAVENS, Jr., Member
Chief, Design Branch
Engineering Division

SAUL COOPER, Member
Chief, Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

THIS SHEET TO BE FURNISHED BY THE CORPS OF ENGINEERS

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 by 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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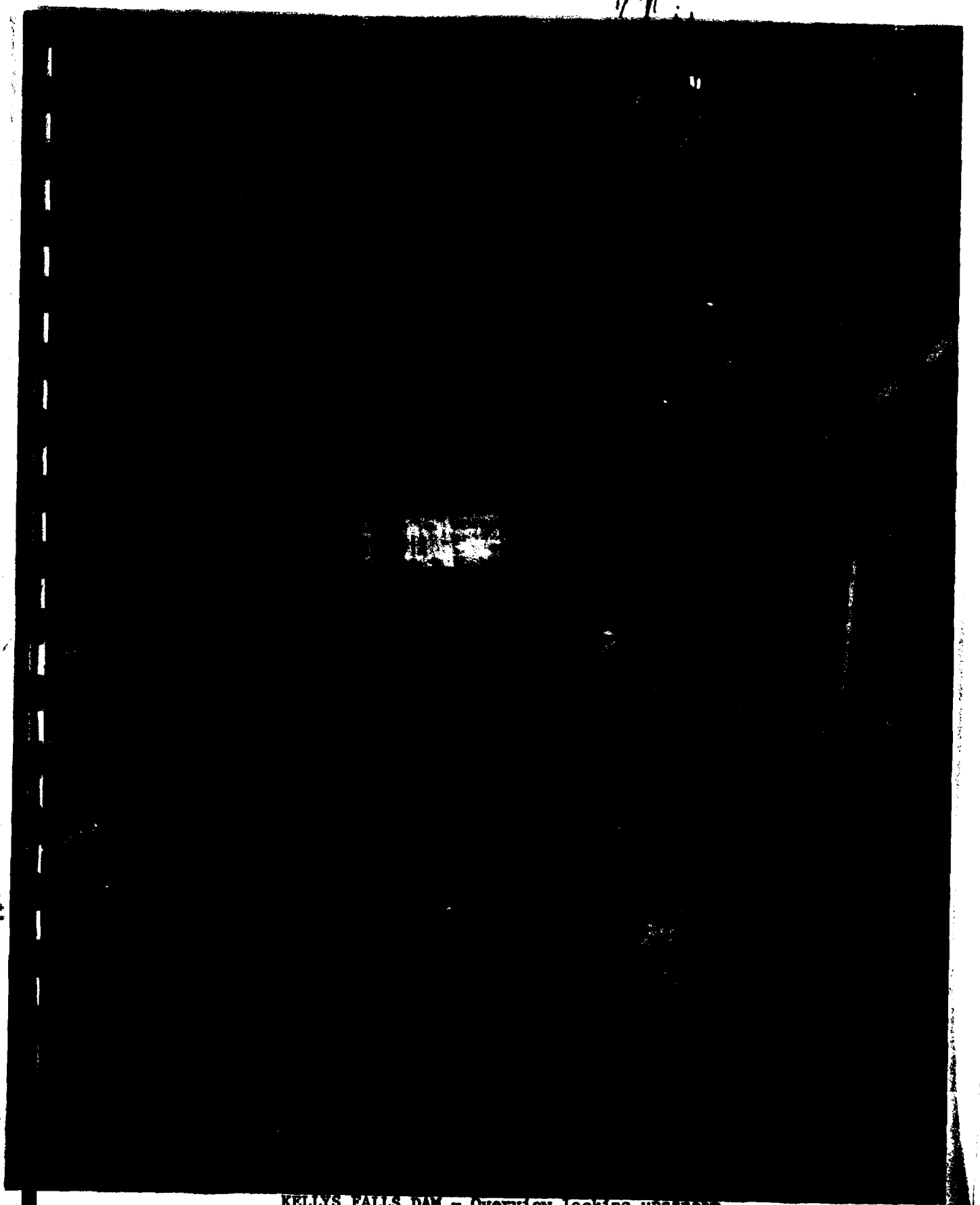

KELLYS FALLS DAM - Overview looking upstream

NATIONAL PROGRAM OF INSPECTION OF NON FEDERAL DAMS

KELLEYS FALLS DAM

LOCATION PLAN

Manchester, N.H.

USGS Quad. Manchester, South

Scale: 1: 24,000

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NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
KELLEYS FALLS DAM

SECTION 1
PROJECT INFORMATION

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. Howard, Needles, Tammen & Bergendoff 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 Howard, Needles, Tammen & Bergendoff under a letter of October 23, 1978 from John P. Chandler, Colonel, Corps of Engineers. Contract No. DACW33-78-C-0356 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. Kelleys Falls Dam is located on the Piscataquog River approximately 1.8 miles upstream of its confluence with the Merrimack River in the City of Manchester, New Hampshire. The dam is shown on U.S.G.S. Quadrangle Manchester South, New Hampshire, with approximate coordinates N42°59'35", W71°29'50" Hillsboro County, New Hampshire. The location of the dam is shown on the preceeding page.

b. Description of Dam and Appurtenances. Kelleys Falls Dam is a "run of the river" type dam. According to available

plans, the overall length is 503 feet. The 192 foot long spillway is a mass concrete structure, which appears to be constructed upon ledge. The spillway appears to have an ogee type shape and has a maximum height of 21 feet. The maximum structural height of the dam is 31 feet. The headgate structure forms the north left abutment and is constructed of stone masonry and concrete. An 11 foot diameter penstock gate is operated from the headworks structure. A wall approximately 284 feet long and constructed of stone masonry follows the northeast bank upstream of the headworks structure. The wall is of varing height. The right abutment is constructed of concrete with a concrete wingwall. The bank above the wingwall is paved with cut granite blocks.

The headworks structure also includes several gates which are no longer in use and are now inoperable. The 6x6 foot gate was used for the power plant condenser intake. The original purpose of the 5x6 foot gate is unknown. In the spillway section of the dam are two pipes; one is a 6 foot diameter condenser discharge line which runs along the axis of the spillway and the other is a 36 inch diameter pipe which runs through the spillway section of the dam near its center. The purpose of this later pipe is unknown. Neither of these pipes are used at present. The gate stem on the right abutment was used to control the condenser discharge gate.

Downstream of the headworks structure is a concrete wall followed by the hydro-building which is now abandoned. The stream bank downstream of the hydro-building is protected by dumped granite block rip-rap.

Figure 1 located in Appendix B, shows the plan of the dam and appurtenant structures. Photographs of each structure are shown in Appendix C.

c. Size Classification. Intermediate (hydraulic height - 31 feet, storage - 2,290 acre-feet) classification based on storage being between 1,000 and 50,000 acre-feet as given in Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification. The hazard to life and property posed by this dam is classified as significant. Failure of this dam at maximum pool elevation would probably result in a total flood wave 12.4 feet high, 1.8 miles downstream. Several homes along the northeast bank would probably be flooded and park land structures would be damaged.

e. Ownership. This dam is presently owned by the New Hampshire Water Resources Board, Concord, New Hampshire. Prior to 1973, the dam was owned by the Public Service Company who obtained the dam and appurtenant structures from Manchester Traction Light and Power Company in 1926.

f. Operator. The dam is operated by New Hampshire Water Resources Board, Concord, New Hampshire, Chairman of the Water Resources Board is Mr. George M. McGee, Sr., Chief Engineer is Mr. Vernon Knowlton, telephone 603/271-1110.

g. Purpose of Dam. Up until 1973, this dam was used to generate electric power. A steam power plant was located adjacent to the existing headworks structure and wall. The impounded water was used for cooling water in a steam power plant and to generate hydro-electric power. At the present time, the impoundment provides some recreational benefits.

h. Design and Construction History. The construction on the existing dam was completed in 1916. Since that time there have been no major modifications to the dam, according to available records.

i. Normal Operational Procedures. Under normal operation the flow over the dam is uncontrolled. From May until October flashboards, 33 inches high, are installed on the dam crest, during the winter months the dam operates at the permanent spillway crest elevation. Normally, the penstock gate is operated only to lower the water level during installation and removal of the flashboards. If high water occurs during the period when the flashboards are in place, the penstock gate is opened. The gate can be opened either manually or by a motor powered by a portable generator. The gate can be opened in about 15 minutes by using the portable generator.

1.3 Pertinent Data

a. Drainage Area. The area tributary to Kelleys Falls Dam consists of 214 square miles of rolling wooded terrain. The drainage area is partially controlled by the Everett Lake Flood control Reservoir, and has the effect of reducing the drainage area by 64 square miles to 150 square miles. The Goffstown Dam at Glen Lake is located about 4 miles upstream of Kelleys Falls, and has little or no effect on flood flows at Kelleys Falls.

The reservoir area is very small in comparison to the total tributary area. Approximately 400 feet upstream of the dam there is a railroad bridge. Further upstream on the northerly bank there are a number of dwellings constructed only a few feet above the spillway crest elevation.

b. Discharge at Dam Site

(1) The present outlet works for the Kelleys Falls Dam consist of a 11 foot diameter penstock and gate set at an invert elevation of 144.4 MSL. Capacity of the penstock with the water surface at the spillway crest elevation is 740 cfs.

(2) Maximum known discharges at the dam site occurred in 1936 and in 1938 with a high water mark recorded at 170.0 feet MSL for each occurrence. Estimated discharge at this elevation is 28,300 cfs. This would indicate overtopping.

(3) The spillway capacity with the water surface at the top of the dam is approximately 21,300 cfs at elevation 168.0.

(4) The spillway capacity with the water surface at the test flood elevation of 174.8 is approximately 46,300 cfs.

(5) The total project discharge at the test flood elevation of 174.8 is approximately 55,900 cfs.

c. Elevation (feet above MSL)

(1) Streambed at centerline of dam - 137.0.

(2) Maximum tailwater - unknown.

(3) Upstream portal invert diversion tunnel - 144.4 (estimated).

(4) Recreation pool - 158.0 winter, 160.75 summer.

(5) Full flood control pool - N/A

(6) Spillway crest (permanent spillway) - 158.0.

(7) Design surcharge - unknown.

(8) Top Dam - 168.0.

(9) Test Flood Surcharge - 174.8.

d. Reservoir (miles)

(1) Length of Maximum Pool - 1.8±.

(2) Length of Recreational Pool - 1.8±.

(3) Length of Flood Control Pool - N/A

e. Storage (gross acre-feet)

(1) Recreation Pool - 1,000.

(2) Flood Control Pool - N/A

(3) Spillway Crest Pool - 1,000.

(4) Top of Dam - 2,290.

f. Reservoir Surface (acres)

(1) Recreation Pool - 129 acres.

(2) Flood Control Pool - N/A

(3) Spillway Crest - 129 acres.

(4) Test Flood Pool - unknown.

(5) Top Dam - unknown.

g. Dam

(1) Type - concrete gravity.

(2) Length - 503 feet overall.

(3) Height - 31 feet.

(4) Top Width - 8.7' maximum.

(5) Side Slopes - The wall along the left bank has vertical faces both up and downstream.

(6) Zoning - none.

(7) Impervious core - none.

(8) Cutoff - unknown.

(9) Grout Curtain - unknown.

(10) Other - none.

h. Diversion and Regulating Tunnel

See Section j below.

i. Spillway

(1) Type - concrete "ogee" shape.

(2) Length of Weir - 192 feet.

(3) Crest Elevation - 158.0.

(4) Gates - Flashboards 33 inches high.

(5) U/S Channel - river channel.

(6) Downstream Channel. Just downstream of the dam there is a bridge with the roadway surface 60+ feet above the river. The channel varies in width from 100 to 200 feet with a regular, stony bed.

j. Regulating Outlets. The 11 foot diameter penstock is now used as the dam outlet works which discharges through the hydro-building. The upstream invert is 144.4 feet. The head gate can be operated by a handwheel or mechanically via a motor and generator which is stored in the hydro-building.

SECTION 2
ENGINEERING DATA

2.1 Design

No original design data were disclosed for Kelleys Falls Dam. Construction of the present dam was completed in 1916. There is no record of any major modifications since the original construction. Plans of the dam showing the general layout and details of the headworks structure were made available.

2.2 Construction

No construction records were available for use in evaluating the dam.

2.3 Operation

During the inspection, it was disclosed that a manual was being prepared which describes procedures for seasonal and emergency operations.

2.4 Evaluation

a. Availability. Engineering data available for Kelleys Falls Dam is limited to the plans described above. These plans are on file with the New Hampshire Water Resources Board, Concord, New Hampshire.

b. Adequacy. The lack of in-depth engineering data did not allow for a definitive review. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance history and sound engineering judgement.

c. Validity. The field inspection indicated that the external features of Kelleys Falls Dam substantially agree with those shown on the available plans.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. The field investigation of Kelleys Falls Dam was made on April 24, 1979 with an second inspection made on May 2, 1979, when the pond level was lowered for installation of flashboards. The inspection team consisted of personnel from Howard, Needles, Tammen & Bergendoff and Geotechnical Engineers, Inc. A representative of the New Hampshire Water Resources Board was also present during the inspection. Inspection checklists, completed during the visual inspection, are included in Appendix A. At the time of the April 24 inspection the water level was about 8 inches above the spillway crest, during the May 9 inspection the water level was several inches below the spillway crest.

b. Dam. Visual inspection of the dam indicated that the dam was in poor condition.

The dam consists of a mass concrete spillway structure about 192 feet in length. The headgate structure is located at the left end. The dam is apparently founded on bedrock. The shape of the spillway is shown on Section A-A, Figure 1, located in Appendix B. A wall, which is an extension of the dam, extends from the left abutment upstream approximately 284 feet and is constructed of cut stone masonry with a concrete cap.

At the time of the April 24 inspection, water was flowing over the spillway, and close visual examination of the upstream face, crest, and downstream face was not possible. No major vertical or horizontal misalignment of the dam was observed.

A memo dated October 8, 1976 states that small seepage was observed on October 5, 1976 at a point approximately 1/4 of the way up the face and in the middle of the spillway.

The crest of the dam appeared to be irregular as shown in Photo 6.

A bedrock outcrop was observed immediately downstream of the dam on the left side, as shown in Photo No. 12.

The April 24 inspection indicated that there was considerable concrete deterioration on the spillway.

The lowering of the pond level on May 9 for flashboard installation enabled a more complete inspection of the mass concrete spillway, however, ponding immediately downstream of the dam prevented further investigation of the spillway foundation.

Photos No. 7 and 10 show the extent of the loss of concrete. Photo No. 7 also shows evidence of leakage through the spillway section. Five large leaks and a number of small leaks were noted across the downstream face of the dam. The locations of the leaks are shown in the Special Elevation, Figure 1, located in Appendix B.

The spillway section of the dam is in poor condition.

The left abutment consists of concrete gravity wall and of large cut-granite blocks with mortar joint training walls. Inspection revealed that the granite blocks and their alignment are in good condition. The concrete surface has deteriorated in the form of cracks, spalling and undermining, see Photos No. 8 and 10. The concrete undermining is located at the upstream water level, adjacent to the intake structure, see Photos No. 11 and 18. All concrete surfaces are cracked and spalled to some degree; it appears to be time related concrete deterioration with lack of periodic maintenance.

The wall to the left of the outlet works is shown in Photo 5. This wall is comprised of cut stone masonry capped with concrete. No vertical or horizontal misalignment of the wall was observed. Mortar was missing from between stone blocks on the west side of the wall, a distance of about 1 to 2 feet above the water level. Water level was 11 feet below the top of the wall. Several stone blocks were missing in one area of the wall near the outlet structure, as shown in Photos No. 11 and 18.

Bedrock was observed at the base of the cut stone masonry wall from its upstream end to a point about 64 feet upstream of the downstream wall of the headgate structure. The base of the remainder of the cut stone wall could not be seen because it was too far underwater.

The east side of the cut stone masonry wall just upstream of the headgate structure is shown in Photo 16, 17. Minor seepage was observed through the stone masonry wall from the upstream end of the headgate structure to about 31 feet upstream of the headgate structure. The highest elevation of the seepage observed was 13.5 feet below the top of the wall or 2.5 feet below reservoir level.

The right abutment is primarily of concrete construction. The inspection revealed that the concrete surface contained cracks, spalling and some erosion at the upstream water level. In general, the right abutment appeared to be in good condition.

Views of the concrete abutment on the right side of the dam are shown in Photos No. 19 and 22. Spalling of this concrete wall was observed near the waterline. Erosion and undercutting of the bank upstream of the right training wall was observed, Photo No. 19.

A large seep was observed at the base of a concrete wall on the right bank downstream of the crest. The seep was coming from around the right side of the abutment, as shown in Photo No. 25. The water appeared to be clear.

Water was flowing over rounded gravel, cobbles, and boulders on the right bank downstream of the right end of the concrete abutment to a point about 35 feet downstream of the concrete wall, as shown in Photos No. 23 and 24.

No seepage from the right bank could be found further downstream (about 500 feet of the bank was examined) that would be caused by natural groundwater flow. The topography of the right bank was similar over the distance examined. This leads to the conclusion that the seepage around the right wall of the dam and over the right bank near the dam is probably related to the reservoir level.

The abutments and wall on the left bank did not show any signs of stability problems.

c. Appurtenant Structures. Visual inspection of the headgate structure and the now abandoned hydro-building did not reveal any evidence of stability problems.

The intake structure (headgate structure) and the now abandoned generating station is a part of the left abutment and is constructed of stone masonry and concrete. The concrete surface is generally in poor condition with cracks, and spalling (see Photos No. 14 and 15). The protection railing at the stairs and the platform was repaired in late April, 1979 by replacing missing sections and now is in good condition. An 11 foot diameter penstock, with an 11x11 foot gate, is operated from the intake structure; the gate and mechanical controls are operational. The penstock structure is the only way of outletting water other than spillway.

The 6x6 foot gate and the 6x5 foot gate were inoperable and closed. The condition of the 6 foot diameter condenser discharge pipe through the spillway section could not be inspected and its condition is unknown. The 36 inch pipe located near the center of the spillway section appears to be plugged.

The now abandoned generating station structure consisting of concrete foundation and brick-structural steel superstructure is in a fair condition. Photo No. 9 taken during low water shows loss of concrete and exposure of steel reinforcing around the hydro-building at the water line.

d. Reservoir Channel. As this is a "run of the river" type dam the reservoir area is very small. About 400 feet upstream of the dam there is a railroad bridge crossing the Piscataquag River. Further upstream there are a number of homes constructed only a few feet above the spillway crest elevation. The amount of siltation behind the dam is unknown.

e. Downstream Channel. Downstream of the dam there is a high roadway bridge, however, the piers do not obstruct the channel. The downstream channel is the natural riverbed, which varies in width from 100 to 200 feet with a fairly regular stony bed.

3.2 Evaluation

Visual examination indicates the dam is in poor condition. The inspection revealed the following:

(a) Considerable loss of concrete on the mass concrete spillway section.

(b) Five major and a number of minor leaks through the concrete of the spillway.

(c) Deterioration of concrete, in the form of cracking and spalling on the left abutment and wall.

(d) Cracking and spalling of concrete on the right abutment.

(e) Several stone blocks missing from the wall on the left bank upstream of the headgate structure.

(f) Minor seepage through the wall on the left bank upstream of the headgate structure.

(g) Seepage around the concrete wall on the right side of the dam and over the right bank immediately downstream of the dam.

(h) Erosion of the right bank upstream of the right training wall.

(i) Loss of concrete and exposure of reinforcing steel at the waterline on the hydro-building.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedure

Prior to 1973, the Kelleys Falls Dam impoundment was used in power production. The impoundment is now used for recreation only as all power producing machinery and most of the associated structures have been removed. During normal operation all flow is over the spillway. During May of each year, 33 inch flashboards are installed to raise the water level until October, when they are removed. The 11 foot diameter penstock is the only outlet now operational. It is opened only to lower the water level during installation and removal of the flashboards or to reduce water pressure on the flashboards when high water conditions occur.

4.2 Maintenance of Dam

The dam is visited once every two weeks by personnel of the New Hampshire Water Resources Board

4.3 Maintenance of Operating Facilities

There is no maintenance schedule for the outlet works facilities. The penstock gate is opened twice yearly or as required. The generator used to operate the penstock gate is started and run each time the site is visited. It was reported that an operations manual was being prepared for Kelleys Falls Dam.

4.4 Description of Warning Systems

There is no warning system in effect in case of the failure of Kelleys Falls Dam.

4.5 Evaluation

The current operation and maintenance procedures for Kelleys Falls Dam appear to be adequate to insure that problems encountered can be remedied in within a reasonable period of time, with the assumption that the operation and maintenance manual will be completed. However, a warning system should be devised to follow in the event of flood flow conditions or imminent dam failure.

SECTION 5
HYDROLOGY AND HYDRAULIC ANALYSIS

5.1 Evaluation of Features

a. General. Kelleys Falls Dam is a concrete and stone masonry structure with an overall length of 503 feet, and a maximum structural height of 31 feet. The 192 foot long spillway is concrete and of an "ogee" type shape. A stone masonry wall is constructed along the northerly bank and varies in height from 1 to 12.5 feet as measured from the ground surface. Outlet works on the northerly abutment consists of an 11 foot diameter penstock controlled by a head gate.

The reservoir impounded by the dam is now used for recreation and is very small as compared with the tributary area. The dam is classified as intermediate in size having a maximum storage of 2,290 acre-feet.

b. Design Data. No hydrologic or hydraulic design data were disclosed for Kelleys Falls Dam.

c. Experience Data. Maximum discharge at this dam site occurred in 1936 and again in 1938. A water surface elevation of 170.0 was noted for both occurrences. Estimated discharge is 28,300 cfs.

d. Visual Observations. No evidence of damage to any portion of the project from overtopping was visible at the time of inspection.

e. Test Flood Analysis. As no detailed design and operational information are available, hydrologic evaluation was performed using dam information gathered by field inspection, watershed size and an estimated test flood equal to ½ the Probable Maximum Flood (PMF) as determined by guide curves issued by the Corps of Engineers, and as modified by Everett Lake. Based on a drainage area of 214 square miles, less 64 square miles, it was estimated that the test flood inflow at Kelleys Falls Dam would be 55,900 cfs. Following the guidance for Estimating Effect of Surcharge Storage on Maximum Probable Discharge does not result in any significant reduction of the test flood discharge. As the maximum spillway capacity at the top of the dam is only 21,300 cfs (approximately 38 percent of the test flood discharge flow), the test flood will result in the dam being overtopped by approximately 6.8 feet.

f. Dam Failure Analysis. The impact of failure of the dam at maximum pool (top of dam) was assessed using the "Rule of Thumb" Guidance for Estimating Downstream Dam Failure Hydrographs issued by the Corps of Engineers. The analysis covered the reach extending from the dam to the confluence of the Merrimack-Piscataquog River 1.8 miles downstream. Prior to breach of dam the downstream river stage, with the spillway at full capacity, would be about 10.2 feet. Failure of the dam at maximum pool elevation would probably result in a total flood wave 12.4 feet high at the end of the reach. Most of the impact area on the southwest bank of the river is park land. On the northeast bank there are several homes. One home is only 6 to 8 feet above normal river stage and there are 3 or 4 dwellings that are about 15 feet above the river. Failure of the dam would cause damage to several dwellings, to park land facilities and some hazard to life.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observation. The visual examination did not disclose any immediate stability problems for the abutments, wall on the left bank or appurtenant structures. Water level on the upstream face of the dam and ponding on the downstream face of the dam prevented a thorough examination of the dam foundation.

b. Design and Construction History. Kelleys Falls Dam consists of a mass concrete spillway and a cut granite wall, with concrete abutments and headgate structure. The dam was completed in 1916. Since that time there have been no major repairs or modifications, according to available records.

Existing plans show a plan of the dam and outlet works and details of the outlet works prior to the removal of the power generating plant.

c. Operating Records. No operating records were made available.

d. Post-Construction Changes. There are no records of any changes made to the dam since its construction in 1916.

e. Seismic Stability. The dam is located in Seismic Zone 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. Condition. The visual inspection of Kelleys Falls Dam indicates that the dam is in poor condition. However, a complete foundation inspection could not be made due to water on the upstream face of the dam, and water ponding, during both inspections, at the base of the dam. The inspections revealed the following:

(1) Considerable loss of concrete on the mass concrete spillway section.

(2) Five major and a number of minor leaks through the concrete of the spillway.

(3) Deterioration of concrete, in the form of cracking and spalling on the left abutment and wall.

(4) Cracking and spalling of the concrete on the right abutment.

(5) Several stone blocks missing from the wall on the left upstream of the headgate structure.

(6) Minor seepage through the wall on the left bank upstream of the headgate structure.

(7) Seepage around the concrete wall on the right side of the dam and over the right bank immediately downstream of the dam.

(8) Erosion of the right bank upstream of the right abutment.

(9) Loss of concrete and exposure of reinforcing steel at the waterline on the hydro-building.

The hydraulic analysis reveals that the spillway can not pass the routed test flood without overtopping the dam.

b. Adequacy of Information. The lack of in-depth engineering data did not allow for a definitive review. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data but is based primarily on visual inspection, past performance history and sound engineering judgment.

c. Urgency. This dam is in generally poor condition. The recommendations given in sections 7.2 and 7.3 should be addressed, unless otherwise specified, within one year after the receipt of this Phase I - Inspection Report by the owner. Recommendations described in Section 7.2a and 7.2b should be addressed within 6 months, remedial measures described in Section 7.3a should be addressed immediately.

d. Necessity of Additional Investigation. Water ponding at the downstream base of the dam prevented a thorough geotechnical investigation of the foundation. An investigation of the foundation should be made when there is no water passing over the spillway and below the downstream face of the dam.

7.2 Recommendations

It is recommended that the owner engage a qualified engineer to:

(a) Make a thorough investigation of the condition of the foundation of the spillway section of the dam.

(b) Investigate the structural stability of the spillway section of the dam.

(c) Evaluate further the potential of overtopping and inadequacy of the spillway.

7.3 Remedial Measures

(a) Remove the flashboards from the spillway section of the dam until a more detailed investigation is made of the structural stability of the spillway, and the results of the investigation are implemented.

(b) Provide protection of the right upstream bank near the concrete abutment.

(c) Monitor seepage areas noted in Section 3.1.b and 3.1.c and relate volume of seepage to reservoir level.

(d) Repair cracking and spalling of concrete on right abutment.

(e) Repair of concrete deterioration on the left abutment.

(f) Repair of missing stones on masonry wall on left bank.

(g) Repair of concrete and exposed steel at the water line on the hydro-building.

(h) Complete the development of a written operational procedure, and develop a warning system to follow in the event of flood flow conditions or imminent dam failure.

(i) A periodic technical inspection program should be initiated and continued on a annual basis.

7.4 Alternatives

There are no practical alternatives to the recommendations of Sections 7.2 and 7.3 except that on an interm basis the owner may consider operating the reservoir at a lower level so as to increase the stability of the dam.

APPENDIX A

INSPECTION CHECKLIST

A-1

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT KELLEYS FALLS DAM

DATE April 24, 1979

TIME 11:00 AM

WEATHER Fair 60°F

W.S. ELEV. 158.8 U.S. - DN.S

PARTY:

1. D. LaGatta	GEI	6.	
2. T. Keller	GEI	7.	
3. S. Mazur	HNTB	8.	
4. R.A. Yarsites	HNTB	9.	
5.		10.	

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Dam	Dan LaGatta, Tom Keller	
2.	Spillway, Outlet and	Stan Mazur, Robert Yarsites	
3.	Downstream Channel		
4.			
5.			
6.			
7.			
8.			
9.			
10.			

A-2

PERIODIC INSPECTION CHECK LIST

PROJECT KELLEY'S FALLS DAM DATE April 24, 1979

PROJECT FEATURE Concrete Gravity Dam NAME D. P. LaGatta

DISCIPLINE Geotechnical Engineer NAME T. O. Keller

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	At time of inspection (4-24-79) water was flowing over the spillway.
Current Pool Elevation	2 ft above dam crest in 1938.
Maximum Impoundment to Date	
Surface Cracks	Surface of dam not visible.
Pavement Condition	No pavement.
Movement or Settlement of Crest	Could not observe.
Lateral Movement	None observed.
Vertical Alignment	No major vertical misalignment observed.
Horizontal Alignment	No major horizontal misalignment observed.
Condition at Abutment and at Concrete Structures	Spalling of concrete walls at abutments near water lines.
Indications of Movement of Structural Items on Slopes	None.
Trespassing on Slopes	Treaspassing on right abutment.
Sloughing or Erosion of Slopes or Abutments	Erosion of right abutment at water line upstream of dam.
Rock Slope Protection - Riprap Failures	Riprap on left bank of downstream channel in good condition.
Unusual Movement or Cracking at or near Toes	Toe not visible.
Unusual Embankment or Downstream Seepage	Seepage at end of concrete wall on right abutment downstream of dam. General seepage from above seepage point to a point 35' downstream.
Piping or Boils	
Foundation Drainage Features	None.
Toe Drains	None observed.
Instrumentation System	None observed.
Vegetation	Trees on right abutment.

PERIODIC INSPECTION CHECK LIST

PROJECT KELLEYS FALLS DAM DATE April 24, 1979

PROJECT FEATURE Intake Channel/Structure NAME D. L., T. K.

DISCIPLINE Geotechnical/Structural/Hydraulic NAME S. M., T. Y.

AREA EVALUATED	CONDITION
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channel	Stone masonry wall forms left training wall of outlet works. Masonry missing for 1 to 2 feet above waterline. Some stones missing in this area.
Slope Conditions	
Bottom Conditions	Rock bottom visible for upstream end of wall. Minor seepage through wall observed for a distance of about 31 feet upstream of trash racks.
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	—
b. Intake Structure	This facility has only power intake structure at now abandoned generating station with 11 foot penstock and control gates. The penstock structure is the only way of outletting water other than spillway. The gate and mechanical controls are operational.
Condition of Concrete	
Stop Logs and Slots	

A-4

PERIODIC INSPECTION CHECK LIST

PROJECT KELLEYS FALLS DAM DATE April 24, 1979

PROJECT FEATURE Control Tower NAME S. Mazur

DISCIPLINE Structural Engineer NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - CONTROL TOWER	
a. Concrete and Structural	This facility has no control tower.
General Condition	
Condition of Joints	
Spalling	
Visible Reinforcing	
Rusting or Staining of Concrete	
Any Seepage or Efflorescence	
Joint Alignment	
Unusual Seepage or Leaks in Gate Chamber	
Cracks	
Rusting or Corrosion of Steel	
b. Mechanical and Electrical	
Air Vents	
Float Wells	
Crane Hoist	
Elevator	
Hydraulic System	
Service Gates	
Emergency Gates	
Lightning Protection System	
Emergency Power System	
Wiring and Lighting System	

PERIODIC INSPECTION CHECK LIST

PROJECT KELLEYS FALLS DAM DATE April 24, 1979

PROJECT FEATURE Transition and Conduit NAME S. Mazur

DISCIPLINE Structural Engineer NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - TRANSITION AND CONDUIT General Condition of Concrete Rust or Staining on Concrete Spalling Erosion or Cavitation Cracking Alignment of Monoliths Alignment of Joints Numbering of Monoliths	The now abandoned 11 foot power generating penstock is used as the outlet works structure. The penstock structure was not inspected as it was well under water. The visual inspection appears to indicate that conduit and the control gate are in good condition.

PERIODIC INSPECTION CHECK LIST

PROJECT KELLEYS FALLS DAM DATE April 24, 1979

PROJECT FEATURE Outlet Structure/Channel NAME S. Mazur

DISCIPLINE Structural/Hydraulic NAME R. Yarsites

AREA EVALUATED	CONDITION
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	
General Condition of Concrete	Poor; abandoned power generating station is part of outlet works structure.
Rust or Staining	Heavy spalling.
Spalling	Badly eroded concrete below normal water level.
Erosion or Cavitation	Visible reinforcing below normal water level. (missing reinforcing cover).
Visible Reinforcing	None observed.
Any Seepage or Efflorescence	Eroded.
Condition at Joints	None observed.
Drain Holes	Channel is river channel.
Channel	None.
Loose Rock or Trees Overhanging Channel	Good.
Condition of Discharge Channel	

PERIODIC INSPECTION CHECK LIST

PROJECT KELLEYS FALLS DAM — DATE April 24, 1979

PROJECT FEATURE Spillway/Discharge Channel — NAME S. Mazur

DISCIPLINE Structural/Hydraulic Engineers — NAME R. Yarsites.

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	Approach channel is river channel.
a. Approach Channel	
General Condition	Good.
Loose Rock Overhanding Channel	None.
Trees Overhanging Channel	None of significance.
Floor of Approach Channel	Rock and probably some silt.
b. Weir and Training Walls	
General Condition of Concrete	Poor.
Rust or Staining	Some staining, at seepage areas.
Spalling	Heavy throughout.
Any Visible Reinforcing	Visible at foundation wall of outlet works structure. (power station)
Any Seepage or Efflorescence	
Drain Holes	No drain holes were found.
c. Discharge Channel	
General Channel	Rock river bed appears to be in good condition.
Loose Rock Overhanging Channel	None.
Trees Overhanging Channel	None of significance.
Floor of Channel	Rock bottom visible near left side of spillway.
Other Obstructions	High level bridge piers.

PERIODIC INSPECTION CHECK LIST

PROJECT KELLEYS FALLS DAM DATE April 24, 1979

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - SERVICE BRIDGE	
a. Super Structure	None.
Bearings	
Anchor Bolts	
Bridge Seat	
Longitudinal Members	
Under Side of Deck	
Secondary Bracing	
Deck	
Drainage System	
Railings	
Expansion Joints	
Paint	
b. Abutment & Piers	
General Condition of Concrete	
Alignment of Abutment	
Approach to Bridge	
Condition of Seat & Backwall	

APPENDIX B
ENGINEERING DATA

1. LIST OF DESIGN, CONSTRUCTION AND MAINTENANCE RECORDS
2. PAST INSPECTION REPORTS
3. PLAN AND DETAILS

AVAILABLE ENGINEERING DATA

A set of drawings (3 sheets) dated July 1914, showing a plan of the spillway and details of the headgate structure are available at the State of New Hampshire Water Resources Board, 37 Pleasant Street, Concord, New Hampshire 03301.

PAST INSPECTION REPORTS

M E M O R A N D U M

DATE: March 7, 1974

FROM: Peter J. Merkes, Water Resources Engineer

SUBJECT: Kelley's Falls Dam

TO: Vernon A. Knowlton, Chief Water Resources Engineer

A meeting was held this date at Kelley's Falls Dam with the following attendance:

Don Rapoza - N.H.W.R.B.
Pat Kesavan "
Pete Merkes "
Parker Farmer - Public Service Co.
Leon Brooks "

Notes and comments from the meeting as follows:

(a) P.S. Co. put flash boards on about May 10 and removed them approximately Nov. 1 of each year. It isn't necessary to open gate for draw-down to install flash boards as they waited until level of river dropped on its own.

(b) Both gentlemen from Public Service remarked that if the flash board height could be reduced from 3 feet to 2 feet or less, this dam would require minimal operation, whereas the 3 foot flash boards create a great deal of gate operation. They said they kept the flash boards at the 3 foot height after their hydroelectric production ceased in order to maintain good public relations.

(c) The flash boards' pin sleeves on the dam are 2 inches diameter.

(d) The flash boards' pins (for the 3 foot flash boards) are 1 3/4" pins.

(e) The old flash boards and pins are presently stored at the Amoskeag Dam - See Mr. Leon Brooks.

(f) Trash rack was replaced about 14 years ago. This trash rack doesn't require a log boom, as there has never been a trash rack plugging problem.

(g) The head gate will open and close (using electric power) without the assistance of the wicker gate.

(h) The wicker gate:
1. Has a mark for the closed position.
2. Opens easy and closes hard.
3. Operates with a hand wheel that shouldn't be left at the building because of vandalism.
4. 3" to 4" open on wicker Gate gives a good slug of water.

(i) Contact Mr. Low Hilliard (Public Service Co.) for assistance to hook-up swithces to electric motor on head gate.

Contact Mr. Bill Cashin, Public Service Co.) to run 220-3 phase electric lines from pole to building.

(j) Mr. Brooks offered to cut the flash baords and to fix the pins at our request when we decide what height flash boards we are going to use. He also offered to make us a new supply of shear pins for the gates at Gregg Falls.

(k) Mr. Farmer has more plans at his office on the 6th flood of the Plaza Building that we should pick up soon.

The following are items of work to do in the near future:

1. Put "No Trespassing" signs on building.
2. Make protective guard for padlock and hasp.
3. Construct stronger metal box to protect head gate motor and future switch.
4. Need electric power to building and hook-up to motor at head gate.
5. Plywood windows (two sides of building) and paint (blue). Green
6. Remove all light posts, old electric boxes and other unnecessary obsolete items on dam.
7. Remove 3 gates - river has to be drained for this.
8. Re-face concrete in area of trash rack - River has to be drained for this.
9. Some trees to be cut upstream of dam across river from gate house.

RJM:js

File

M E M O R A N D U M

DATE: September 19, 1973

FROM: Pattu D. Kesavan, Water Resources Engineer

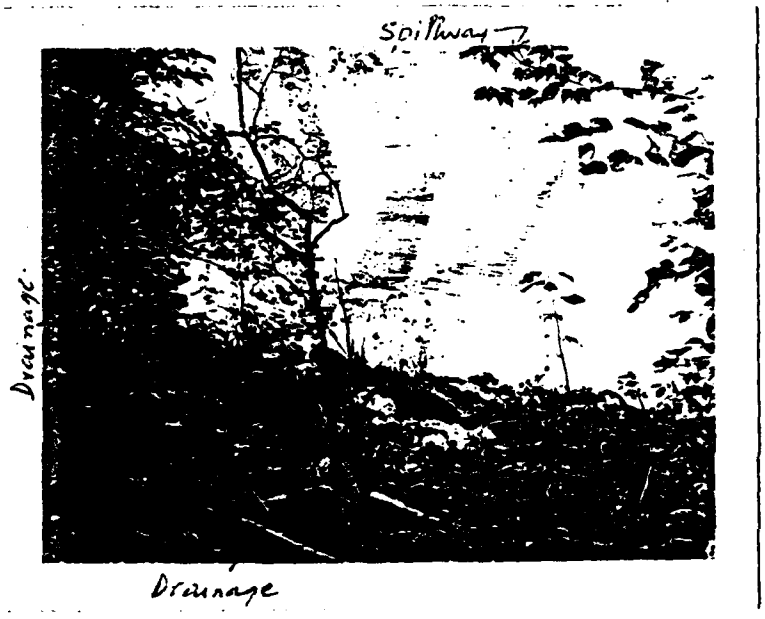
SUBJECT: Kelley's Falls Dam #150.02 in Manchester

TO: Vernon A. Knowlton
Chief Engineer, Water Resources Board

Mr. Morse's memo of September 17, 1973, states that on September 14, 1973, he observed a great deal of water emanating from under and beside the rip-rap on the northwest side wing at Kelley's Falls dam in Manchester.

I inspected the area on September 19, 1973, and found that the water seeping beside the rip-rap of which Mr. Morse complained, is the spring water draining from the steep hill on the northwest side of Kelley's Falls dam.

PDK:js
cc: H.A. Morse, Project Agent



Downstream side of the dam. Arrows show the spring on the northwest side.

P.D.K.
9/19/73

KELLEYS FALLS DAM

MANCHESTER, N. H.

A thorough inspection, study and discussion have to be made before we take over the dam. The following are my comments:

	Comments
1. Paragraph 3 One man can control the wicket gates under normal circumstances.	This has to be practically tried out during inspection. What has to be done under other circumstances? Can two men handle it?
2. Paragraph 4 A 7.5 H.P., 220-V electric motor will be left installed, except that there will be no power supply.	Is there a chance to get the power supply?
A crew would have to be assigned to operate the steel head gate.	How many men in a crew would be needed for this? This has to be checked out.
3. Paragraph 6 Removing or re-installing the boards will ordinarily require a crew of four men working eight hours.	Do we have provision for the cost of operating this? Can we assign four men for the job in a short notice?
4. Paragraph 6 In the fall, there may be periods of heavy leaf accumulation on the racks.	Can one man clean the racks? How often does this have to be cleaned during the fall season?
5. Paragraph 7 Residents are rather sensitive about the pond level; either low or high.	This would be a nuisance, as people will be calling in most of the time, and we have to dispatch at least two men to do the operation. With only two dam operators in hand, this will pose a major problem.

6. Paragraph 8 It is recommended that the three-foot high boards be cut down to two-foot high boards.	Comments It may be even worthwhile studying whether the flash boards be cut down into either 1'6" or 1'0" size. A cost estimate has to be prepared on this.
7. Paragraph 9 Vandalism is a problem in the area of the dam and headworks.	This will cause more concern, as it will not only involve in stealing and breaking, but also in the operation of the gate, etc. Someone has to check the building and the area periodically.

We also have to check into the accessibility and the Right of Way to the dam.

PDK:js
1/29/73

Peter D. Kiamos
1/29/73

DATE: December 6, 1971

FROM: Francis C. Moore, P.E.
Water Resources Engineer

SUBJECT: Kelley's Falls Dam - No. 150.02

TO: Vernon A. Knowlton
Chief Water Resources Engineer

The Corps of Engineers estimate that the 100 year peak flow in Piscataquog River at Grasmere (U.S.G.S Stream Gauge) is 13,000 c.f.s. due to modification by control at Everett Flood Control Dam. (Standard Project flood flow is 42,000 c.f.s.).

At Kelley's Falls dam, the spillway is 197 feet long with 10 feet freeboard from permanent crest and 7 feet from top of flashboards. Based upon 100 year peak flow as modified, the head would be 7.35 feet at the dam. With flashboards failed, there would be 2.65 feet freeboard on abutments. If flashboards height was replaced with concrete, there would be about 4" over top of abutments. Based upon head and efficiency, the 11 foot diameter penstock would pass about 710 c.f.s. if full open.

Based upon 710 c.f.s. through the gate, the maximum flow of 12,290 c.f.s. over the spillway rises 7.1 feet over the spillway.

As the shores upstream of Kelley's Falls dam have houses and camps not too much higher than full pond level, it is imperative that the capacity of the gate section be at least partly maintained. To do so, the gate opening could be cut down to 6' X 6' from 11' diameter circular and still pass the same flow as through the wheel with 11' diameter penstock. It might be possible to raise the permanent crest by 24" if the gate were operated each spring and during high water.

Normal flow is about 4000 c.f.s. If the gate were open, the head on spillway at this discharge is 3 1/3 feet, 2 1/3 feet above full pond with 4000 c.f.s discharge. With 12" surcharge and no gate opening, the flow would be about 660 c.f.s. or 3.1 c.f.s./sq. mi. This would be at level of full pond with 3' flashboards. This flow occurs about 15% of time. With a normal minimum flow of 1/4 c.f.s./sq. mi., there would be 0.2' on the spillway crest.

My recommendations are that the permanent crest be raised 24" and the gate or gates have a total of 36 Sq. ft. opening - preferable 4 - 3' X 3' gates - which will be operated by electric motors. Pressure to lift assuming friction of 10% is 1000 pounds on each gate. These gates should open into the present hydroelectric penstock.

FCM/jb

DATE: November 17, 1971

FROM: Francis C. Moore, P.E.
Water Resources Engineer

SUBJECT: Kelley's Falls Dam

TO: Vernon A. Knowlton
Chief Water Resources Engineer

On October 29, 1971, In inspected Kelley's Falls Hydro Station - #150.02 dam. I took two photos of the dam from downstream left (below power plant building). After viewing, I arranged to get pertinent drawings of the dam and penstock from the Engineering Department of Public Service Company of New Hampshire.

A study of the penstock reyeals that the headgate is the only control of the flow from the pond via the penstock. There are no wickers as at Greggs Falls to assist in opening and closing the head gate. At present, the turbine is held still while a small opening in head gate fills the penstock prior to opening the main head gate.

Some method of double gating must be arranged to successfully operate the penstock. As this spillway is only about 40% as long as the one at Greggs Falls upstream, the gate and penstock are urgently needed.

At present, there are three foot flashboards on the spillway and have been kept on all winter recently. There is ten foot freeboard over the concrete spillway which will pass 20,800 c.f.s. with no flashboards. If the dam were raised three feet, it would pass only 12,200 c.f.s. The 1936 flood flow was 19,900 c.f.s. which was unaffected by dam failures. (21,900 c.f.s. when Deering and Weare Reservoirs failed). From the above data, it appears that the penstock at Kelley's Falls should be maintained as it will pass about 800 c.f.s. raising the total to 21,600 c.f.s. or about 8% more than record flood flows. With Everett Flood Control Dam, there has never been more than 4,320 c.f.s. since its operation ten years ago. This flow would raise water 3.5 feet over spillway with no penstock discharge. With flashboards off, this is only 6 inchesover full pond.

Concerning change in direction of discharge from the penstock, it would be possible to discharge to the left instead of straight line flow from the penstock if changes in the power house were made. This might cut discharge via penstock by 20% due to having flow cut acress discharge from the spillway.

In summary, the capacity of Kelley's Falls dam is not as great as at Greggs Falls. Due to development upstream on the left bank, sizable increases in pond level would not be welcomed.

FCM/jb

M E M O

FROM: Gary L. Kerr
Civil Engineer II

DATE: October 8, 1976

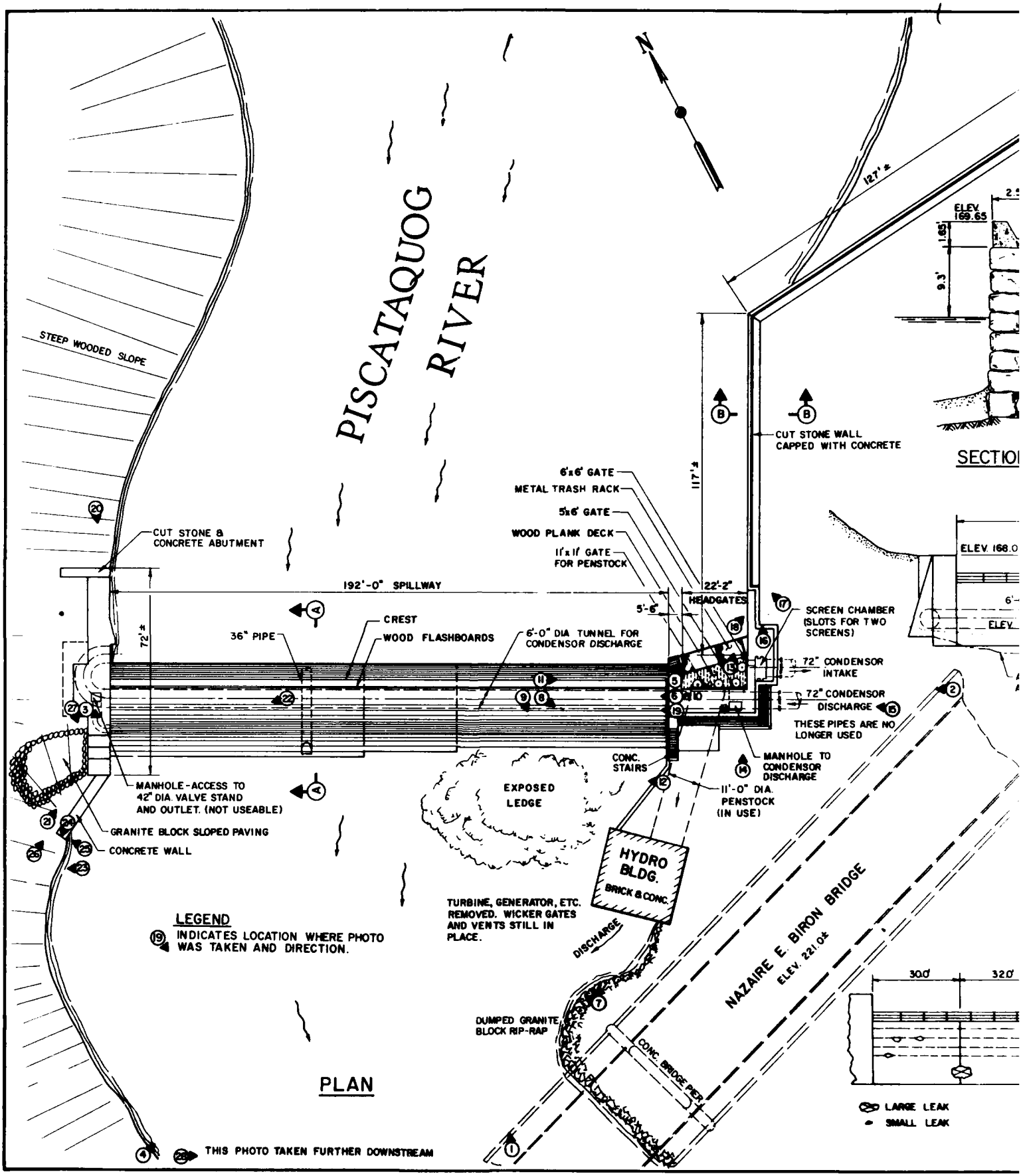
SUBJECT: Leak thru Kelley's Falls Dam spillway

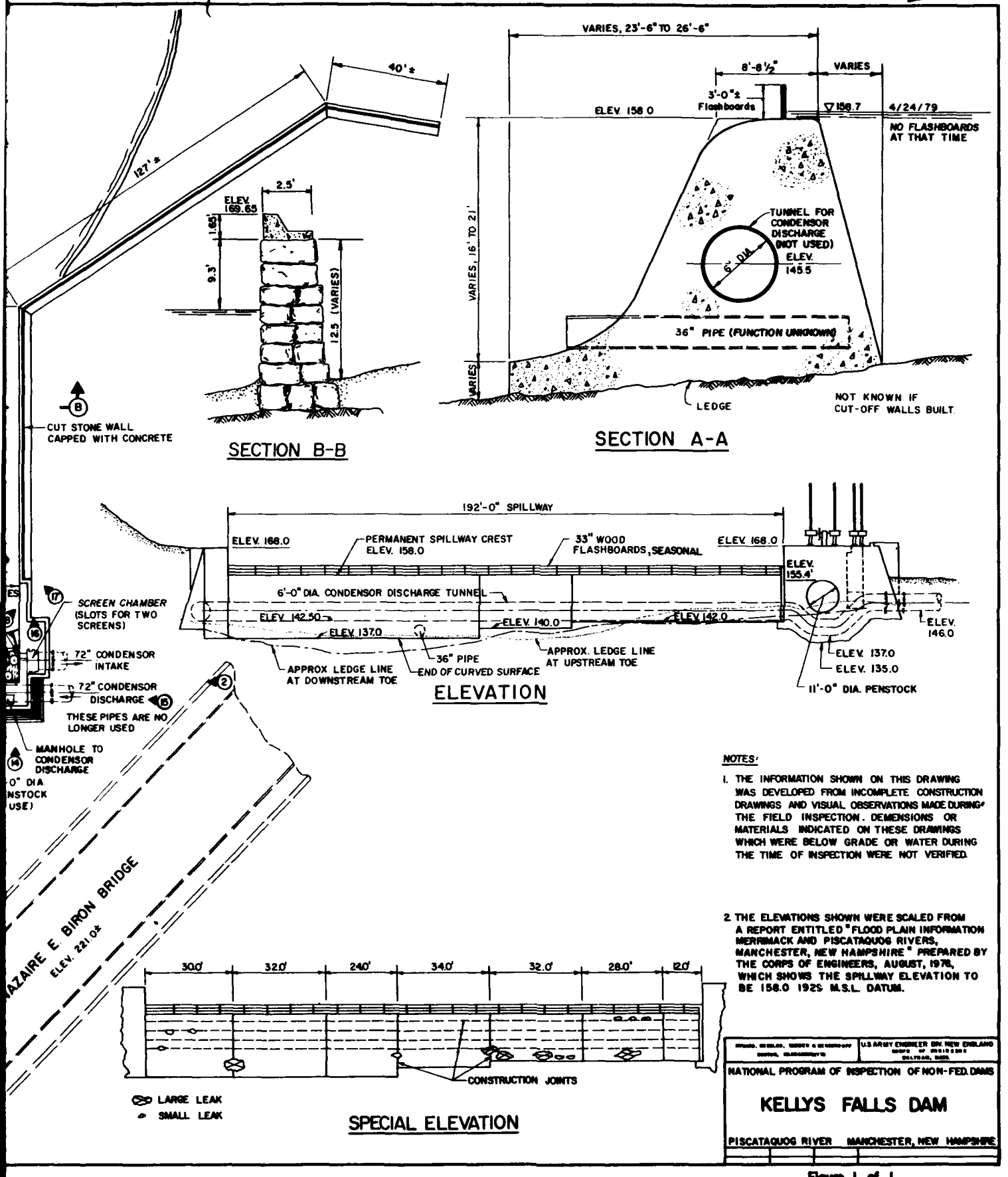
TO: Peter J. Merkes
Civil Engineer IV

On the 5th of October '76, I helped Lyall & Bob remove the flashboards from Kelly's. In the process we observed a small seepage at a point approx. 1/4 of the way up the face and in the middle of the spillway. It appeared to be between two pour lifts and at a fairly steady flow.

GLK/kn

GLK


PISCATAQUOG RIVER
STEEP WOODED SLOPE
CUT STONE & CONCRETE ABUTMENT
192'-0" SPILLWAY
72'±
CREST
WOOD FLASHBOARDS
36" PIPE
6'-0" DIA TUNNEL FOR CONDENSOR DISCHARGE
6'x6' GATE
METAL TRASH RACK
5'x6' GATE
WOOD PLANK DECK
11'x11' GATE FOR PENSTOCK
117'±
22'-2"
HEADGATES
5'-6"
CUT STONE WALL CAPPED WITH CONCRETE
SCREEN CHAMBER (SLOTS FOR TWO SCREENS)
72" CONDENSOR INTAKE
72" CONDENSOR DISCHARGE
THESE PIPES ARE NO LONGER USED
MANHOLE TO CONDENSOR DISCHARGE
11'-0" DIA. PENSTOCK (IN USE)
CONC. STAIRS
EXPOSED LEDGE
MANHOLE-ACCESS TO 42" DIA. VALVE STAND AND OUTLET. (NOT USEABLE)
GRANITE BLOCK SLOPED PAVING
CONCRETE WALL
HYDRO BLDG. BRICK & CONC.
TURBINE, GENERATOR, ETC. REMOVED. WICKER GATES AND VENTS STILL IN PLACE.
DISCHARGE
NAZAIRE E. BIRON BRIDGE
ELEV. 221.0±
DUMPED GRANITE BLOCK RIP-RAP
CONC. BRIDGE PIER
LEGEND
INDICATES LOCATION WHERE PHOTO WAS TAKEN AND DIRECTION.
THIS PHOTO TAKEN FURTHER DOWNSTREAM
PLAN
ELEV 169.65
1.65
9.3'
127'±
ELEV. 168.0
30.0'
32.0'
LARGE LEAK
SMALL LEAK



NOTES:

1. THE INFORMATION SHOWN ON THIS DRAWING WAS DEVELOPED FROM INCOMPLETE CONSTRUCTION DRAWINGS AND VISUAL OBSERVATIONS MADE DURING THE FIELD INSPECTION. DEMENSIONS OR MATERIALS INDICATED ON THESE DRAWINGS WHICH WERE BELOW GRADE OR WATER DURING THE TIME OF INSPECTION WERE NOT VERIFIED.

2. THE ELEVATIONS SHOWN WERE SCALED FROM A REPORT ENTITLED "FLOOD PLAIN INFORMATION MERRIMACK AND PISCATAQUOG RIVERS, MANCHESTER, NEW HAMPSHIRE" PREPARED BY THE CORPS OF ENGINEERS, AUGUST, 1975, WHICH SHOWS THE SPILLWAY ELEVATION TO BE 158.0 192S M.S.L. DATUM.

U.S. ARMY ENGINEER DIV. NEW ENGLAND

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

KELLYS FALLS DAM

PISCATAQUOG RIVER MANCHESTER, NEW HAMPSHIRE

Figure 1 of 1

2

APPENDIX C

PHOTOGRAPHS

FOR LOCATION OF PHOTOS, SEE FIGURE 1
LOCATED IN APPENDIX B

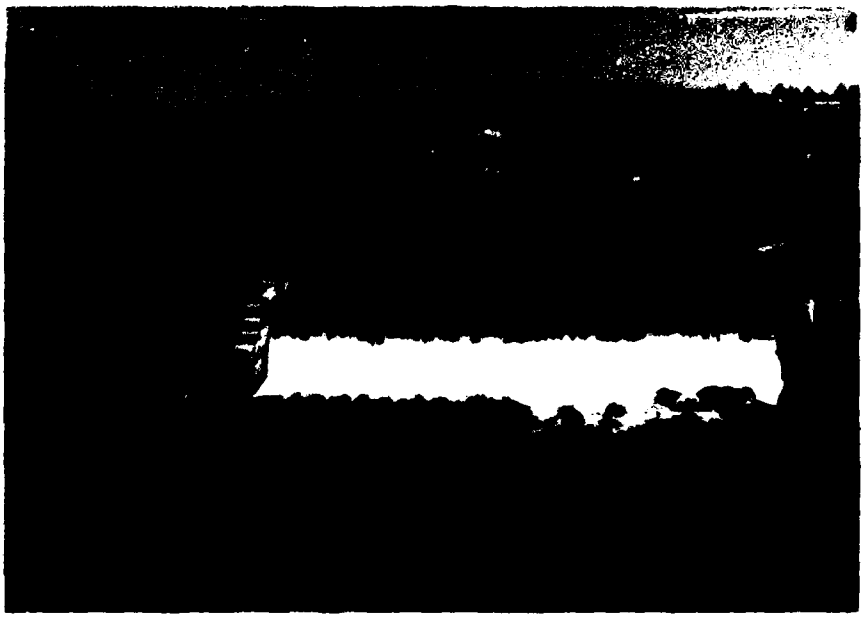


PHOTO NO. 1 - View of spillway and reservoir.

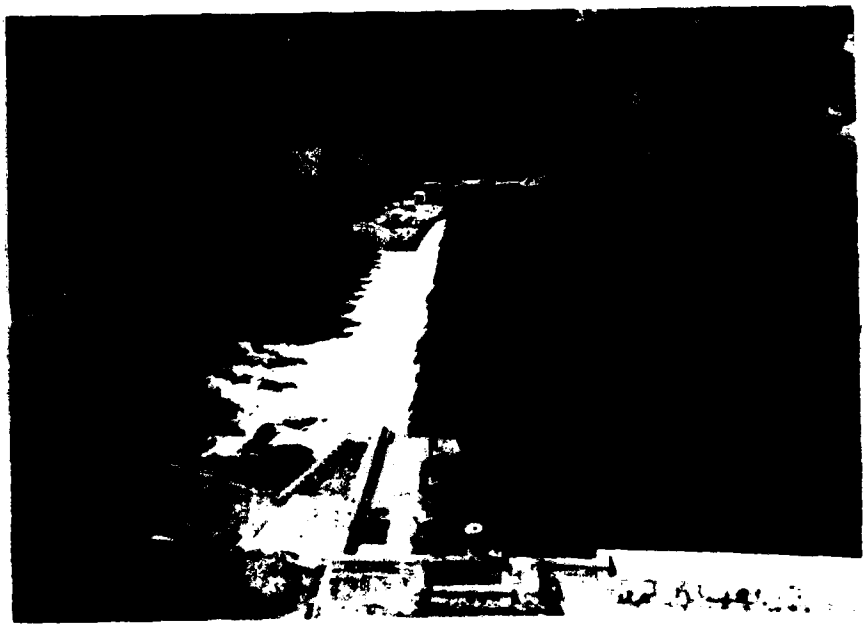


PHOTO N0. 2 - View of head gate structure, spillway and southerly abutment.

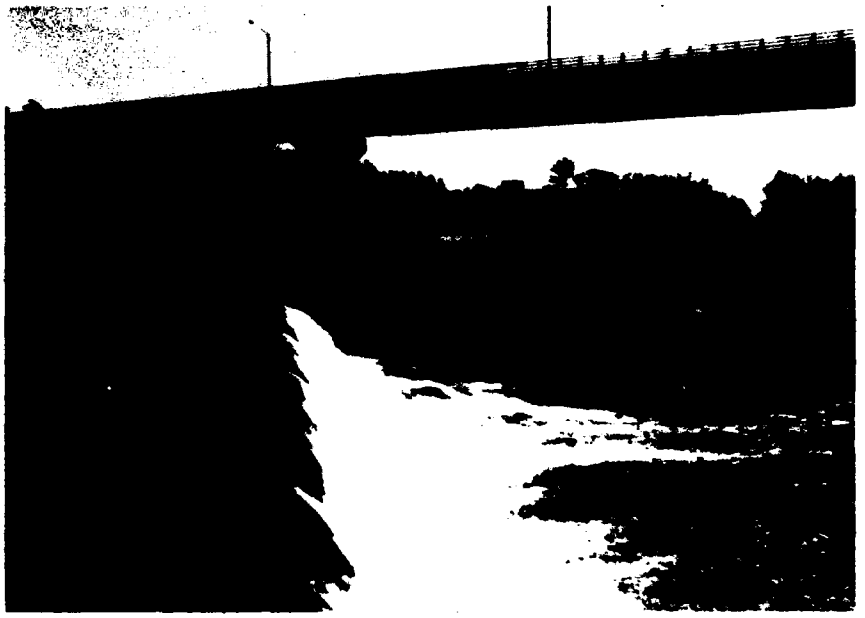


PHOTO NO. 3 - View of head gate structure and hydro-building from right abutment.

PHOTO NO. 4 - View of downstream side of spillway and hydro-building.

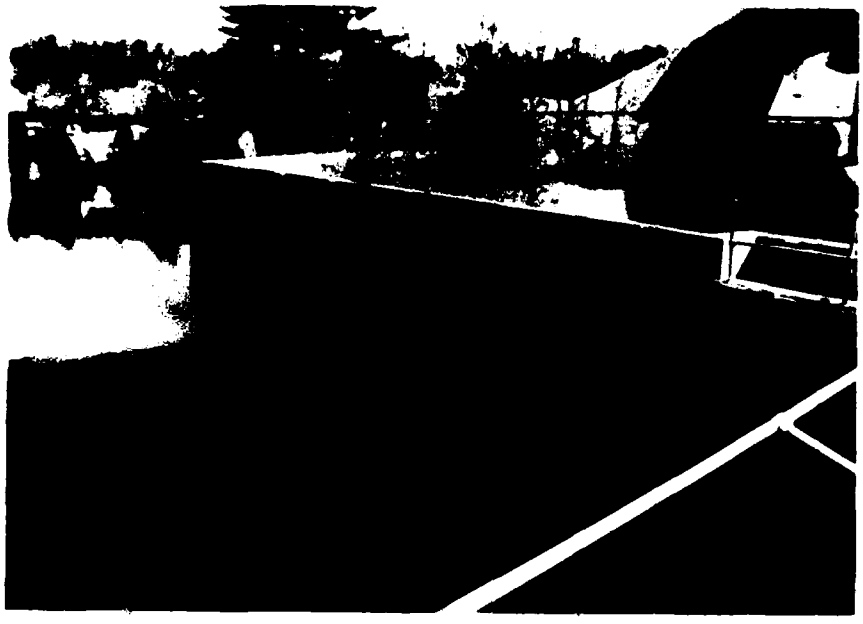


PHOTO NO. 5 - View of wall upstream of dam on left bank.

PHOTO NO. 6 - View of spillway crest detail from left.

PHOTO NO. 7 - View of downstream face of spillway and downstream side of hydro-building.

PHOTO NO. 8 - View of left wall downstream of spillway.

PHOTO NO. 9 - View of side of hydro-building.

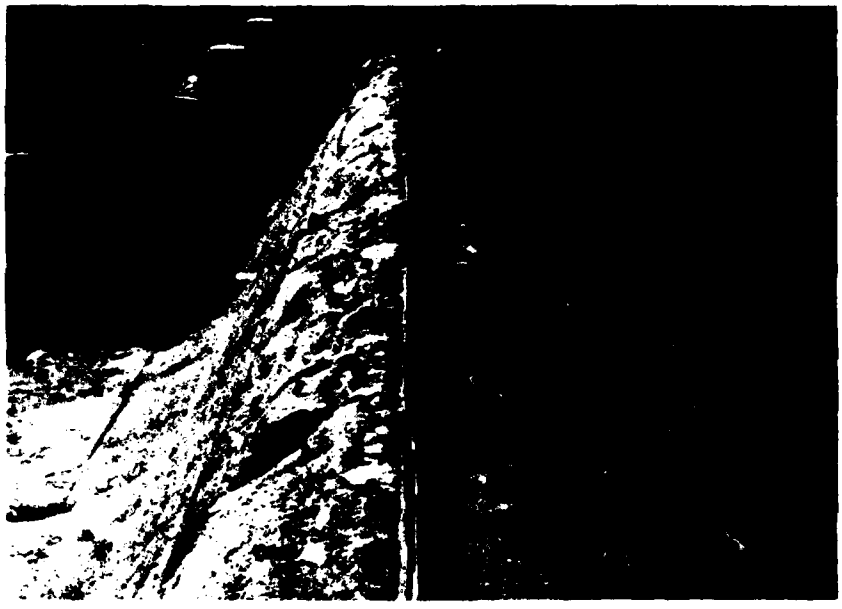


PHOTO NO. 10 - View of spillway crest with flashboards.

PHOTO NO. 11 - View of gate house and portion of wall on left bank.

PHOTO NO. 12 - View of bedrock outcrop at bottom of spillway near left end.

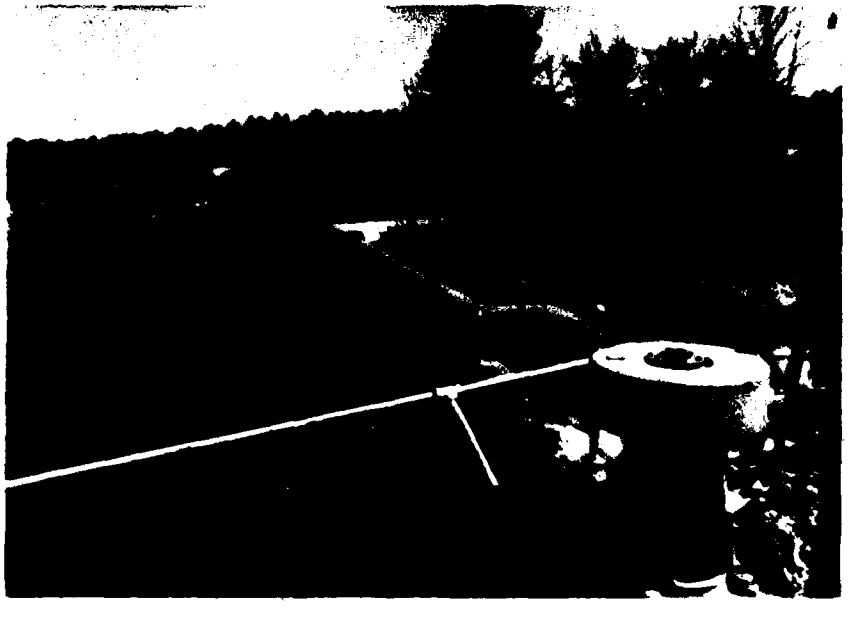


PHOTO NO. 13 - View of wall along left bank and portion of head gate structure.

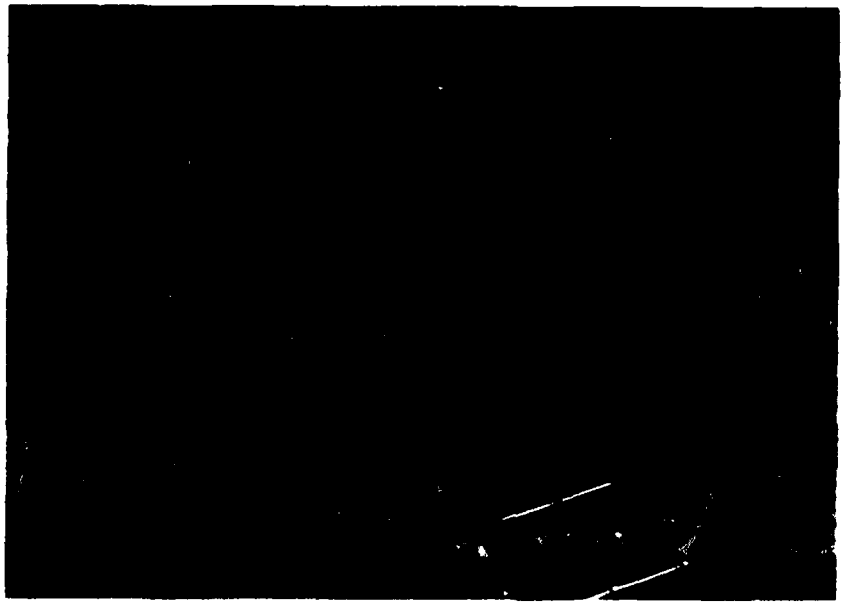


PHOTO NO. 14 - View of downstream side of head gate structure.

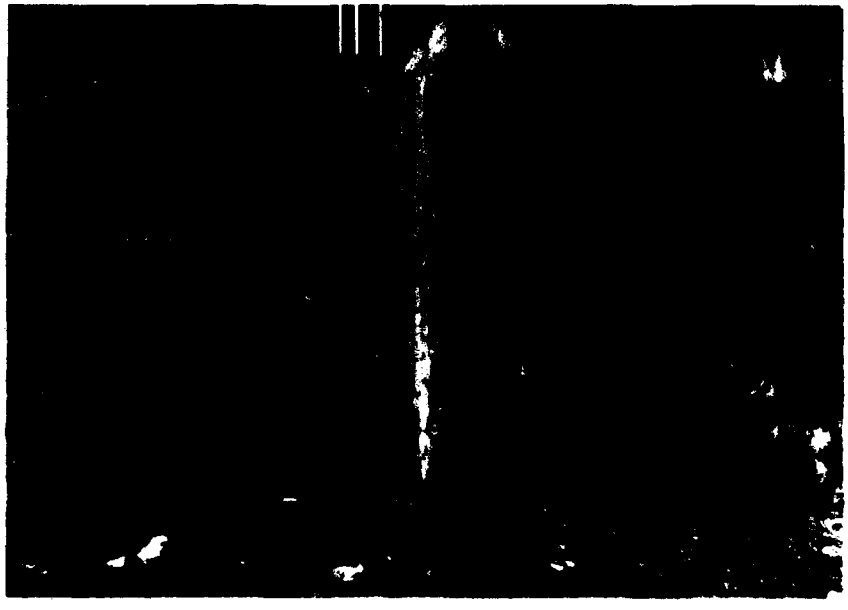


PHOTO NO. 15 - View of head gate structure.

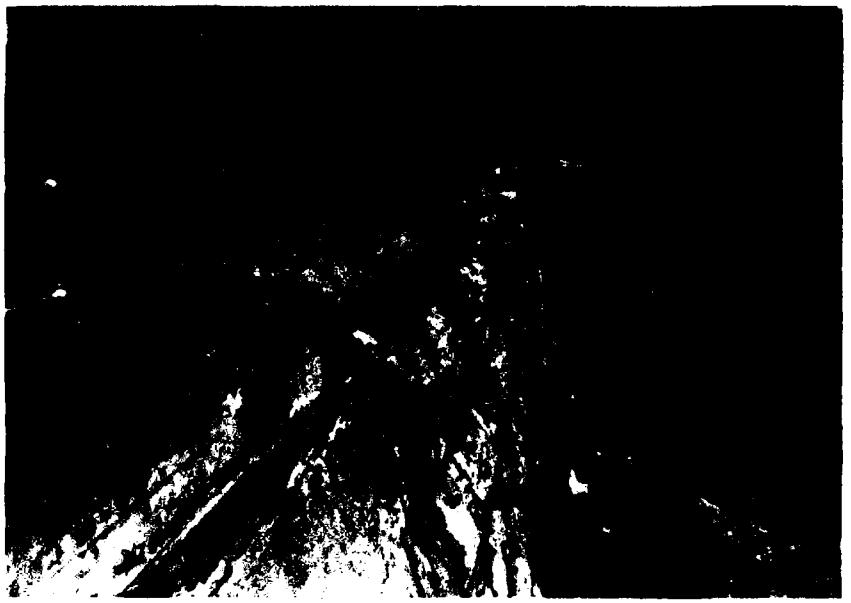


PHOTO NO.16 - View of wall along left bank.

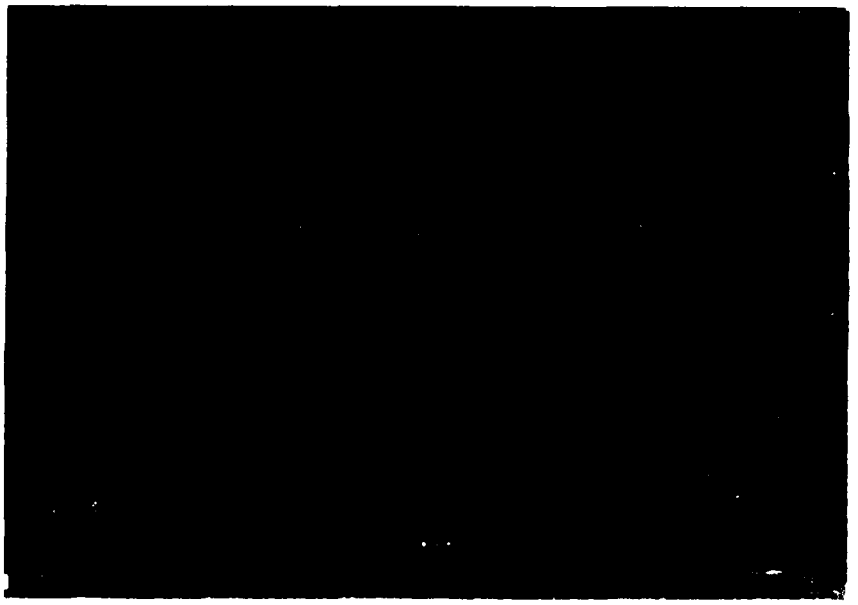


PHOTO NO. 17 - View of wall along left bank.

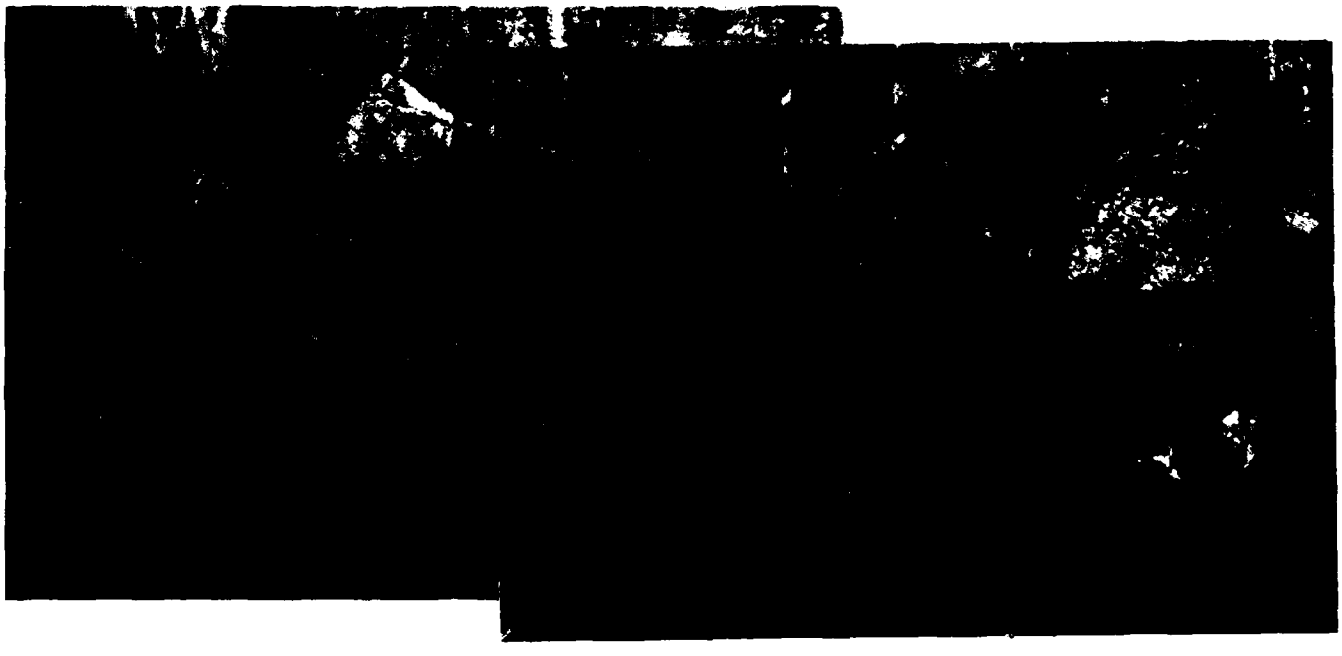


PHOTO NO. 18 - View of eroded area of left training wall from left abutment.

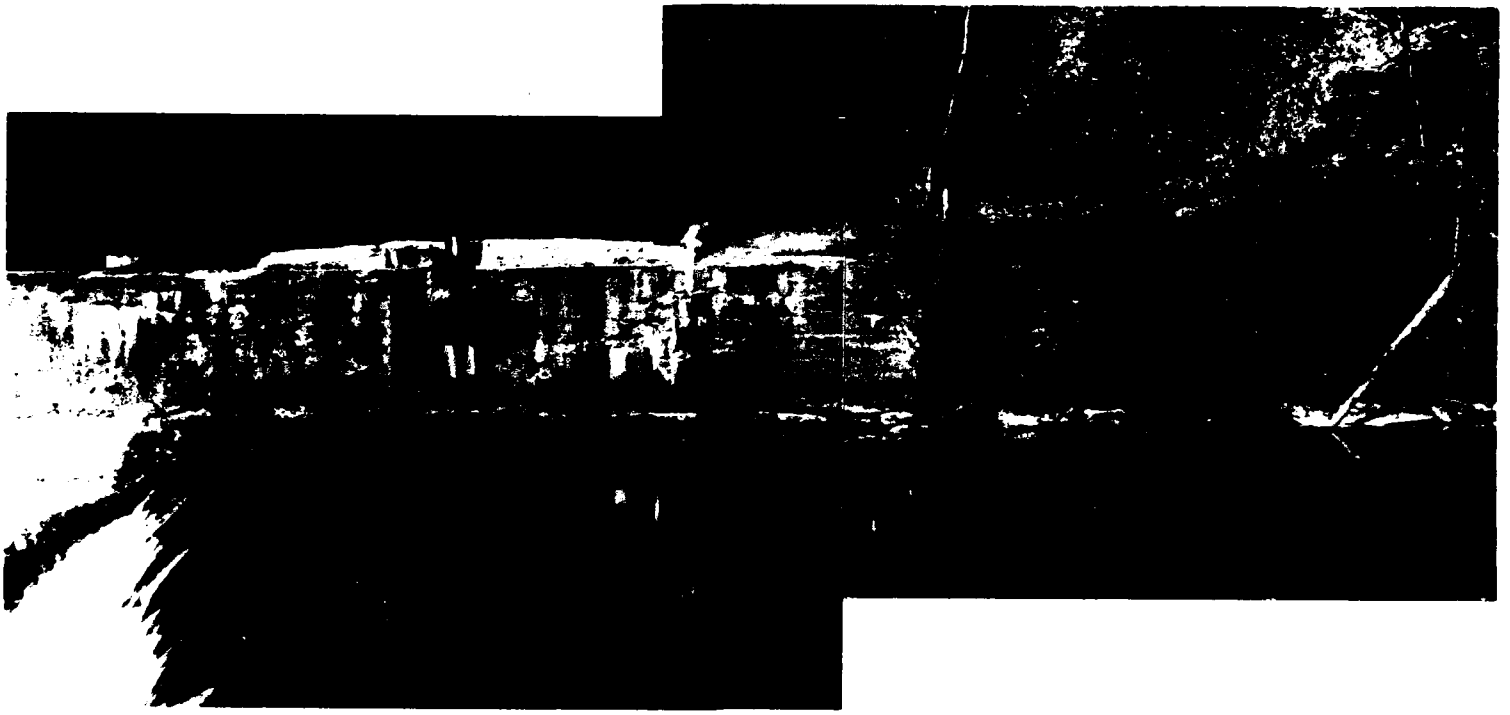


PHOTO NO. 19 - View of right training wall of spillway upstream of crest.

PHOTO NO. 20 - View of top of southerly abutment.

PHOTO NO. 21 - View of downstream portion of southerly abutment.

PHOTO NO. 22 - View of downstream end of right training wall of spillway.

PHOTO NO. 23 - View of seepage through right bank downstream of dam.

PHOTO NO. 24 - Overall view of seepage through right bank downstream of dam.

PHOTO NO. 25 - View of large seep at right end of wall downstream of crest and on right abutment.

PHOTO NO. 26 - View of cut granite blocks downstream of right abutment.

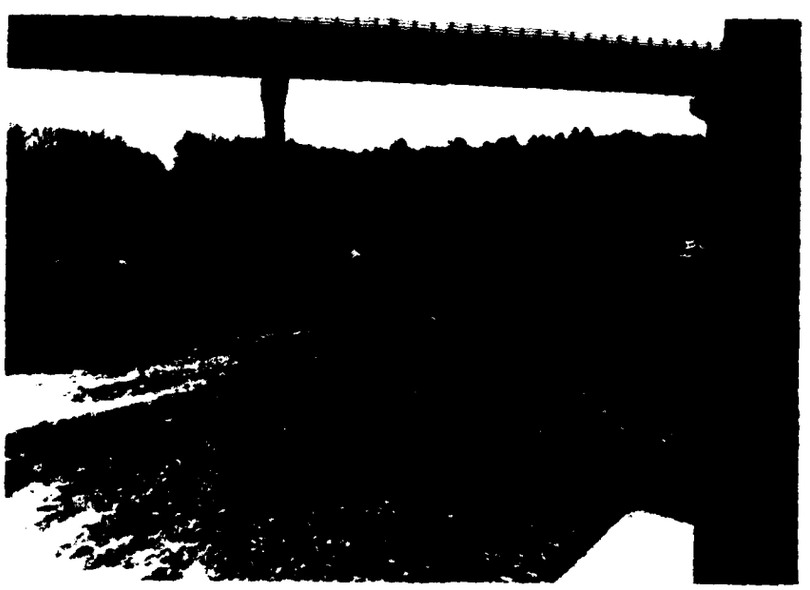


PHOTO NO. 27 - View of channel immediately downstream of dam.

PHOTO NO. 28 - View of channel and left bank about 0.8 mile downstream of dam.

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

HNTB Howard Needles Tammen & Bergendoff	Made by RY	Date 12/5/78	Job No. 5628-11-15
	Checked by [illegible]	Date 5/15/79	Sheet No. 1
For Kelleys Falls Dam			

HYDRAULICS & HYDROLOGY

Kelleys Falls Dam Located in Manchester N.H.

across the Piscataquog River in the Merrimack River Basin.

Classification size: intermediate
hazard: significant

Basic Data D.A. = 214 sq.mi.
Upstream Basin Rolling to flat

Reservoir: Normal pool elev 100.0*
Storage: 1000 acre ft
Max pool elev. 110.0
Storage 2290 acre-ft
Surface Area 129 acres

Dam: concrete gravity?
Length: 504 ft overall
Height 21 ft structural
31 ft max hydralic

Spillway: concrete weir
Length: 192 ft
Crest elev. 100.0

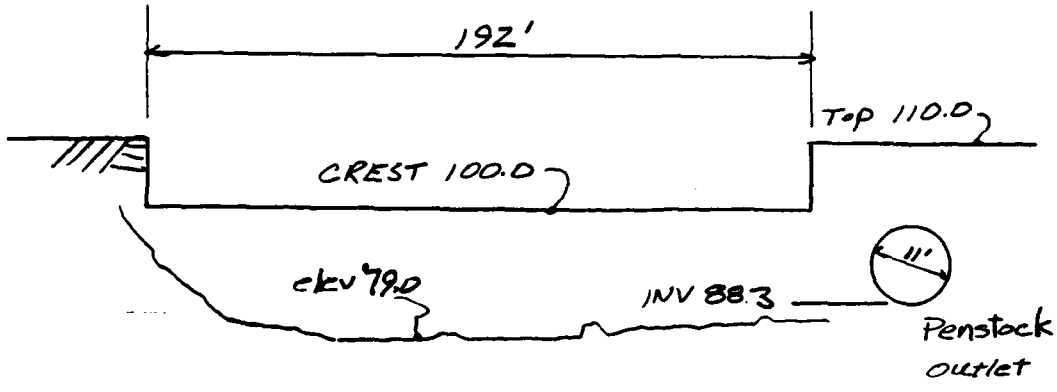
Outlet: Penstock 11' ϕ
invert 88.3

* project datum used.

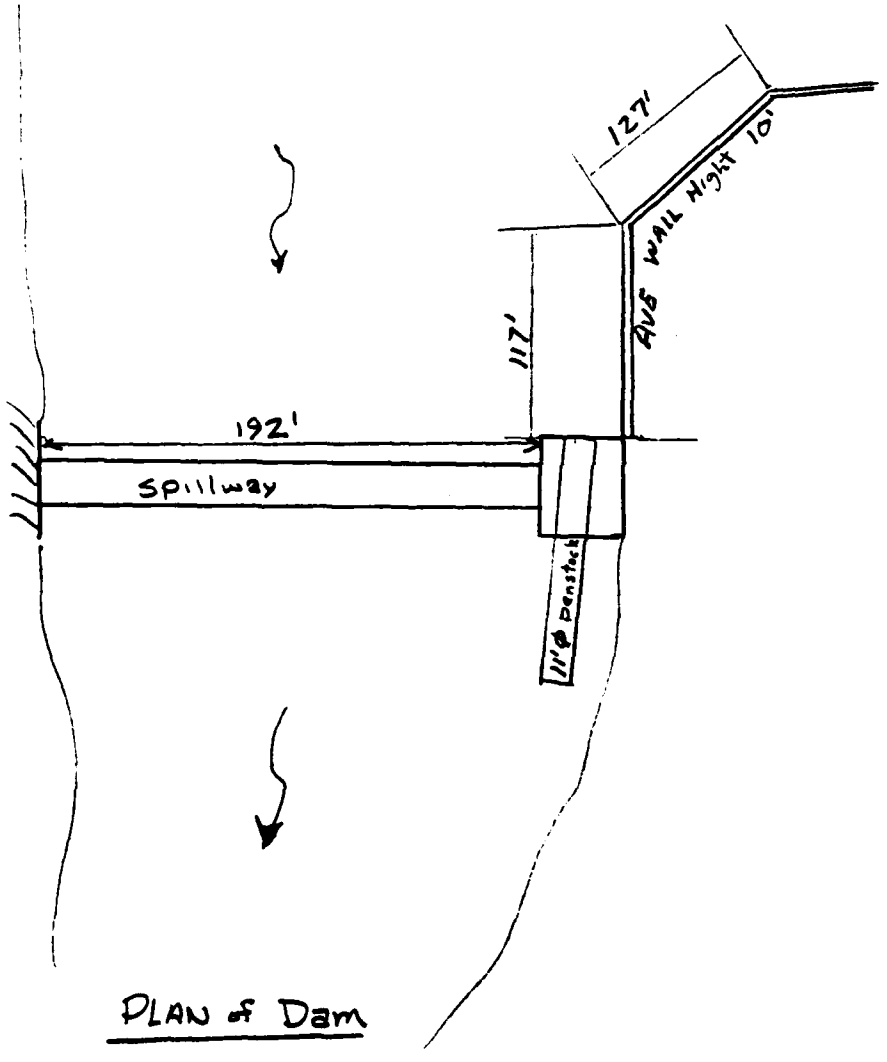
HNTB
HOWARD NEEDLES TAMMEN & BERGENDOFF

Made by RY	Date 12/5/78	Job No. 5628-11-15
Checked by DNB	Date 5/15/79	Sheet No. 2

For Kelleys Falls



Longitudal Section of Dam



PLAN of Dam

HNTB
HOWARD NEEDLES TAMMEN & BERGENDOFF

Made by RY	Date 6/18/79	Job No. 5628-11-15
Checked by [illegible]	Date 7/17/79	Sheet No. 3

For Kelleys Falls

Step 1 Calculation of Test Flood Inflow

Classification : Size : Intermediate
Hazard : significant

Hydrologic Evaluation Guideline Recommends

1/2 PMF to PMF

As size classification is on lower end of classification range of values use 1/2 PMF

Record Flows @ Hoffstown Gage DA. 202 sq.mi.

March 1936	19,900 cfs	"gage"	16.03'
March 1938	21,900 cfs	"	17.52'

Effect of Everett Lakes Reservoir:
COE recommends that drainage basin can be reduced by 64 sq mi to 150 sq. mi to account for storage in Everett Lake.

PMF = 752 csm from Rodling guide curve

752 csm x (214 - 64 sq mi) x 1/2 = 56,400 csm

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 5/1/79	Job No. 5628-1-15
	Checked by [illegible]	Date 5/15/79	Sheet No. 4
For Kelleys Falls			

Step 2 Surcharge By Test Flood

$Test\ Flood_{inflow} = 56{,}400$ cfs

Consider: 1. Penstock gate closed
2. Flashboards down
3. Flow over most of wall on NE bank

Spillway crest = 100

$Q = CLH^{3/2}$

where $C = 3.50$

$L = 192$ ft

$Q = 3.50(192)H^{3/2} = 672H^{3/2}$

Wall crest = 111.65

$Q = CLH_w^{3/2}$ ~ $H = H - 111.65'$

$C = 350$

$L = 244$ ft

$Q = 854(H - 11.65)^{3/2}$

Stage Discharge Curve See fig 1

Elev	H	Qs	Hwall	Qwall	QTotal	Fig 2 TW
105	5.0ft	7510	-		7500	87.4 ok
110	10.0	21250	-		21300	89.4 ok
112	12.0	27930	.35	180	28,100	91.3 ok
114	14.0	35200	2.35	3080	38,300	93.1 ok
116	16.0	43,010	4.35	7750	50,800	95.6 ok
117	17.0	47,100	5.35	10580	57,700	97.1 ok

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 5/2/79	Job No. 5628-11-15
	Checked by [illegible]	Date 5/15/79	Sheet No. 5
For Kelleys Falls Dam			

Penstock if used

use orifice flow $Q = Ca\sqrt{2gH}$ $C = .60$

Has measured from top of penstock elev 97.4

$Q = .6 \times 95.03 \times 8.02\sqrt{H}$

@ Elev 110 $Q_{penstock} = 1620$ cfs

Step 3 Effect of Storage surcharge on SDF

Q_{P_1} inflow = 55,900 cfs

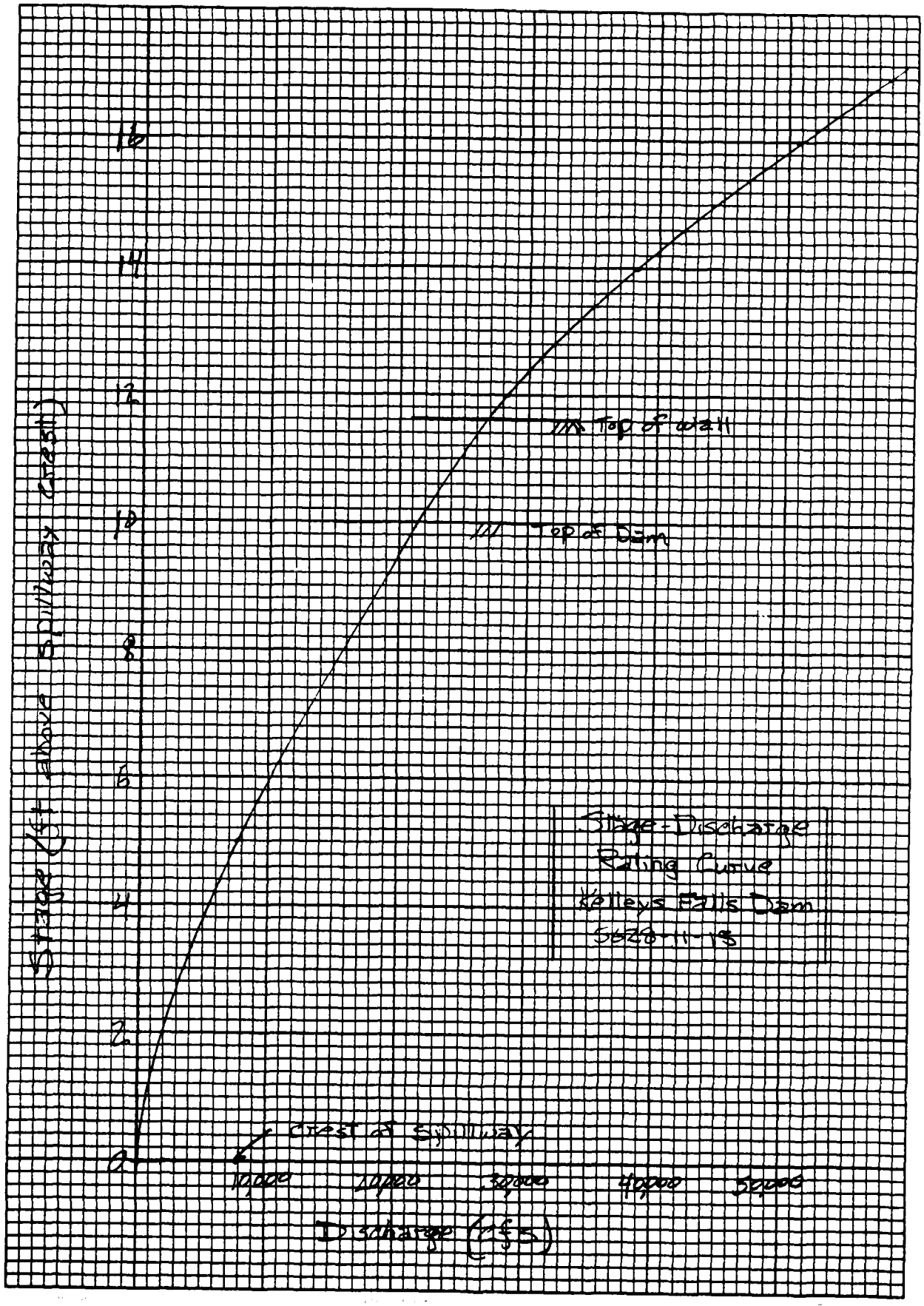
As Storage is very small compaired to runoff volume effect will be negligble

Storage at top of dam
2290 acre-ft

Volume of Run off
$19'' \times \frac{1}{2} \times 214 \text{ sq mi} \times 640 \frac{\text{acre}}{\text{mi}^2} \times \frac{1 \text{ ft}}{12 \text{ in}} = 108{,}400 \text{ acre-ft}$

Conclusions

1. Reservoir storage will not modify SDF
2. The spillway capacity will pass 38% of the test flood
3. At the test flood discharge of 55,900cfs the dam will be overtopped by 6.8 ft - elev 174.8 MSL


Stage (ft above spillway crest)
16
14
12
10
8
6
4
2
0
Top of wall
Top of Dam
Crest of Spillway
10000
20000
30000
40000
50000
Discharge (cfs)
Stage-Discharge
Rating Curve
Kelleys Falls Dam
5628-11-15

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 12/5/78	Job No 5628-11-15
	Checked by MWB	Date 5/15/79	Sheet No 6
For Kelley's Falls Dam.			

Estimate of Downstream Damage

Step 1 Reservoir Capacity

Normal Pool 1000 acre-ft storage @ elev 100.0

Max Pool 2290 acre-ft storage @ elev. 110.0

Step 2 Peak Failure Outflow

$Q_{P_1} = 8/27 \sqrt{g}\, W_b\, Y_o^{3/2}$

W_b = 40% of dam length = 40%(192) & 40% 244'

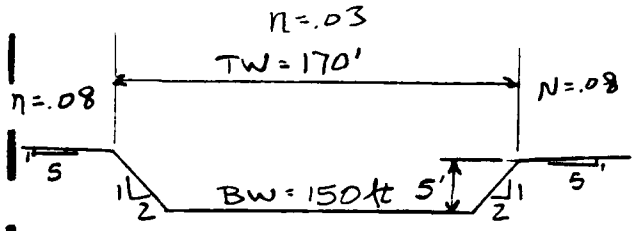
Y_o = height from river bed to max pool = 31 ft Main Dam
= Ave height from ground to top of wall = 10 ft

$Q_{P_{1_{MAIN}}} = 8/27 \sqrt{g}\,(.40)(192)(31)^{3/2} = 22{,}300$ cfs Main Dam

$Q_{P_{1_{WALL}}} = 8/27 \sqrt{g}\,(.40)(244)(10)^{3/2} = 5190$ cfs WALL

$Q_{P_1} = 27{,}490$ cfs

Step 3 Stage-Discharge Rating Curve



Reach Characteristics

L = 9,500 ft

S = .003 ft/ft

n = 0.03

Stage	Discharge
5 ft.	6108 cfs
10	20,622
13	32,790
15	42,290
18	58,630

HNTB
HOWARD NEEDLES TAMMEN & BERGENDOFF

Made by	RY	Date	5/1/79	Job No	5628-11-15
Checked by	[illegible]	Date	5/15/79	Sheet No	7

For

STEP 4
Downstream Floodwave

60% of Maximum spillway flow + Breach outflow

$Q_{P_1} = 60\%(21{,}250) + 27{,}490 = 40{,}240$ cfs

Stage, 14.5 ft $A_1 = 2866$ sq ft

$$V_1 = \frac{2866 \times 9500}{43560} = 625 \text{ acre-ft} < \frac{2290}{2}$$

Reach length OK

$$Q_{P_{2\,Trial}} = Q_{P_1}\left(1 - \frac{V_1}{S}\right) = 40{,}240\left(1 - \frac{625}{2290}\right) = 29{,}260 \text{ cfs}$$

$Stage_2 = 12.15$ ft $Area_2 = 2271$ sq ft

$$V_2 = \frac{2271 \times 9500}{43560} = 495 \text{ acre-ft}$$

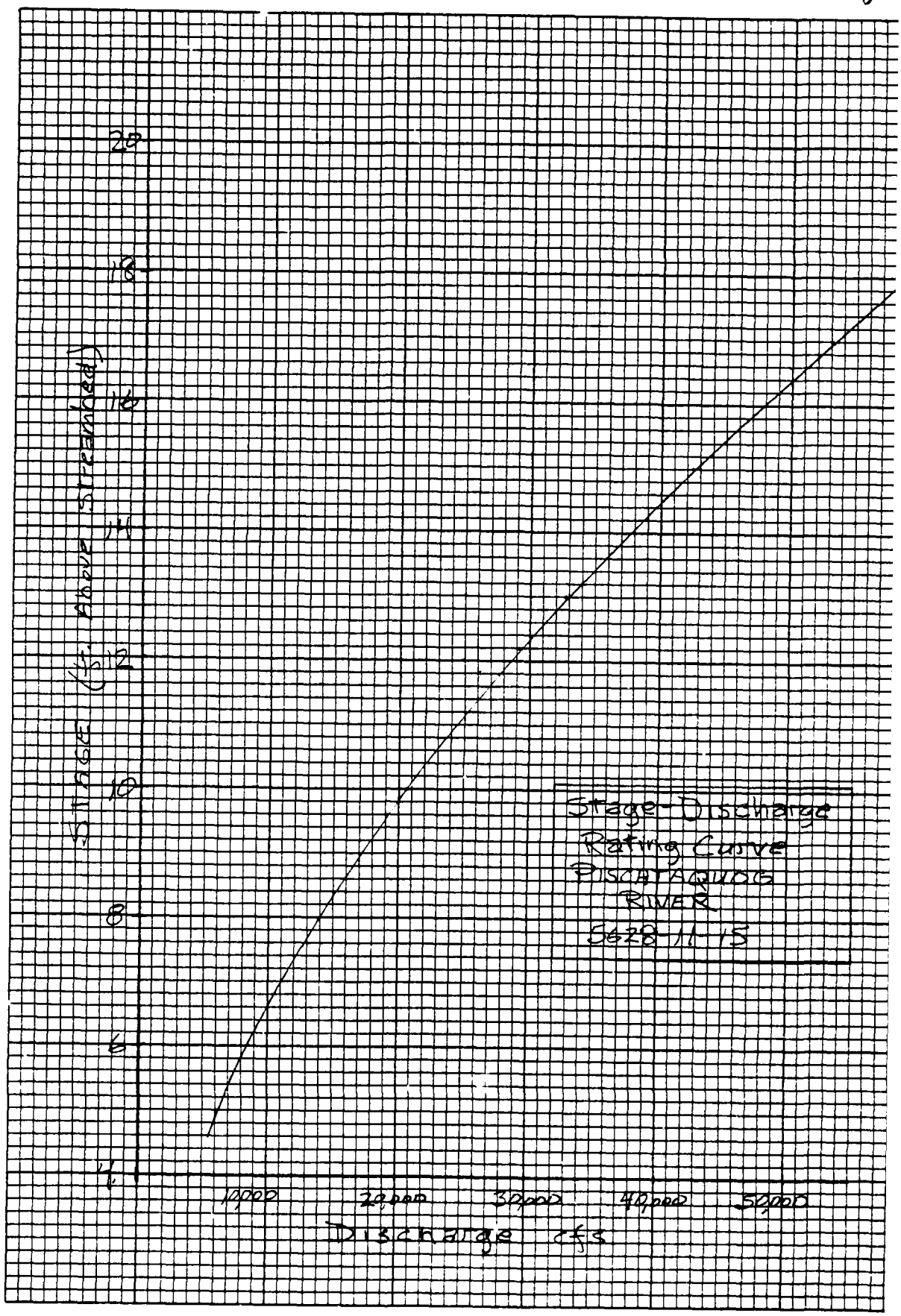
$$V_{Ave} = \frac{V_1 + V_2}{2} = \frac{625 + 495}{2} = 560 \text{ acre ft}$$

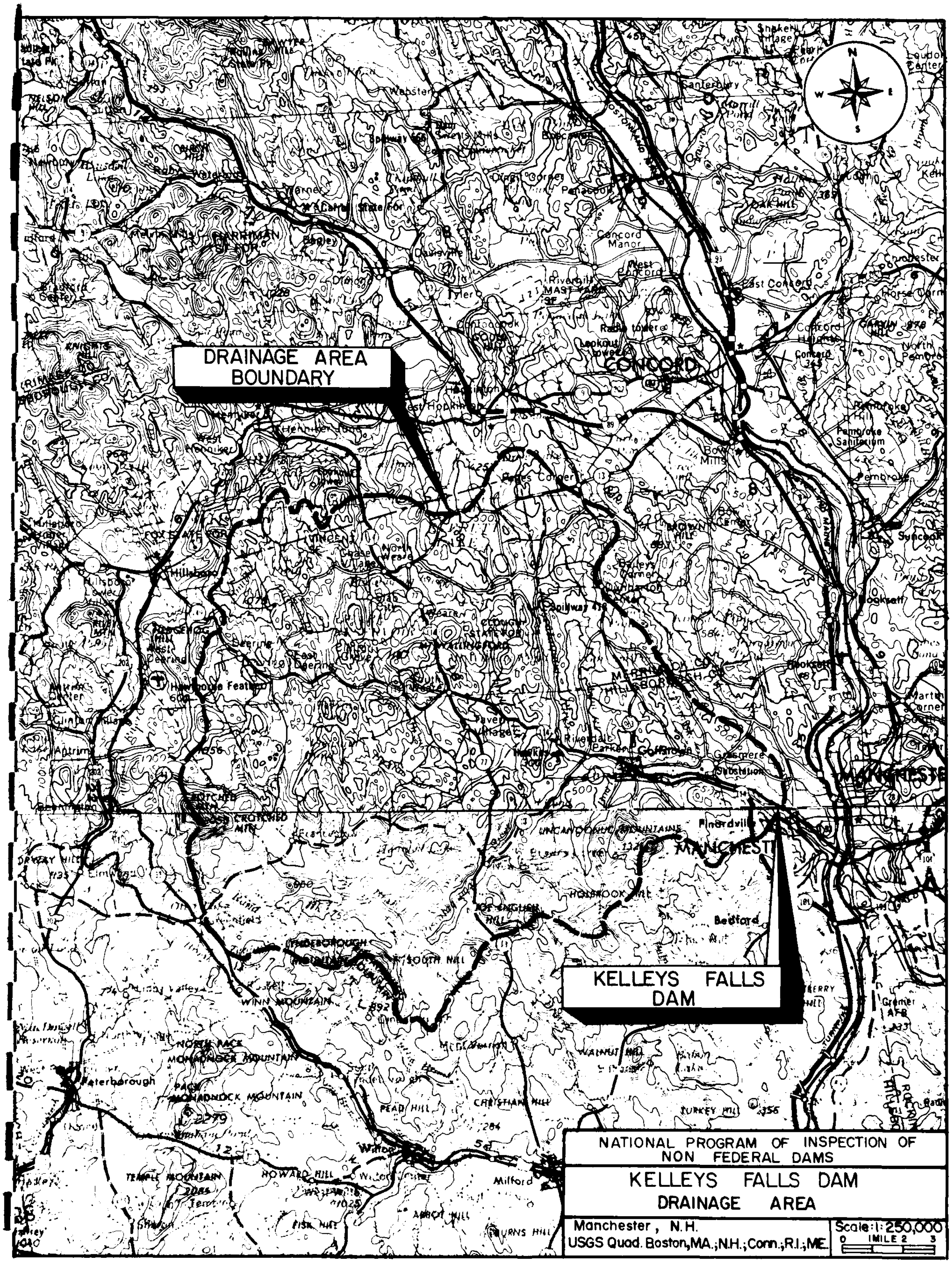
$$Q_{P_2} = 40{,}240\left(1 - \frac{560}{2290}\right) = 30400 \text{ cfs}$$ Stage 12.4 ft

Summary

End of Reach	Stage
At dam	14.5 ft
9500' d.s. of dam at confluence w/ Merrimack R.	12.4 ft

ME101 3/4 20M


Stage-Discharge
Rating Curve
PISCATAQUOG
RIVER
5628 11 15
Stage (ft above benchmark)
Discharge cfs
10000
20000
30000
40000
50000
4
6
8
10
12
14
16
18
20


DRAINAGE AREA BOUNDARY
KELLEYS FALLS DAM
CONCORD
MANCHESTER
NATIONAL PROGRAM OF INSPECTION OF NON FEDERAL DAMS
KELLEYS FALLS DAM
DRAINAGE AREA
Manchester, N.H.
USGS Quad. Boston, MA.; N.H.; Conn.; R.I.; ME.
Scale 1:250,000
0 1 MILE 2 3

NATIONAL PROGRAM OF INSPECTION OF NON FEDERAL DAM

KELLEYS FALLS DAM

POSSIBLE FLOOD DAMAGE AREA

Manchester, N.H.

USGS Quad. Manchester, South

Scale: 1: 24,000

0 FEET 3000

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

END

DATE
FILMED

8 -85

DTI