AD-A154 898 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS JACKSON PLANT DAM NH. (U) CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV FEB 79

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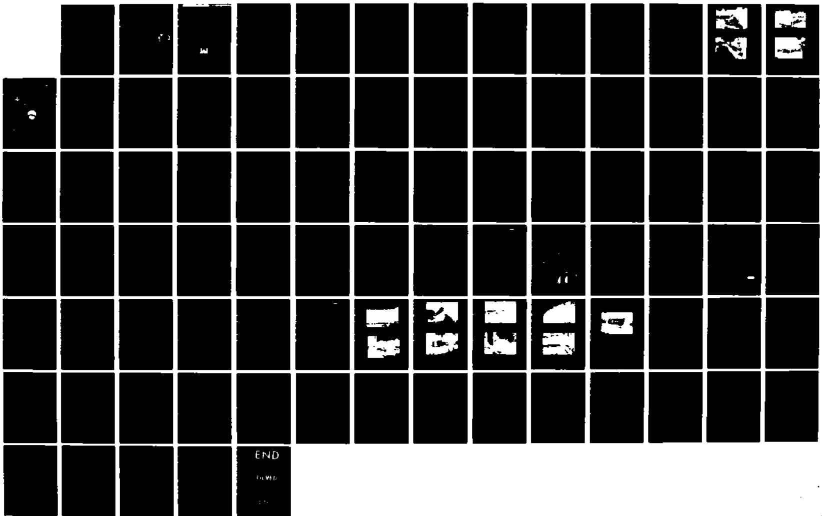

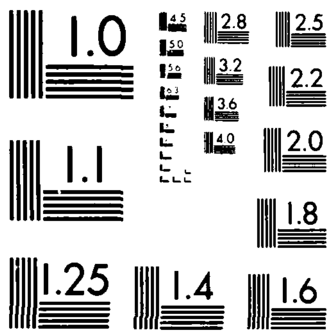

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JACKSON PLANT DAM

NH 00121

NHWRB 165.02

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MERRIMACK RIVER BASIN
NASHUA, NEW HAMPSHIRE

JACKSON PLANT DAM
NH 00121
NHWRB 165.02

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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

FEBRUARY 1979

UNCLASSIFIED

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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
Nashua, New Hampshire
Nashua River

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

THe dam is a 33 ft. high gravity concrete and gravity stone masonry dam capped with concrete. It is about 400 ft. long. It is small in size with a significant hazard potential, The dam is in fair condition at the present time. There are various remedial measures that the owner should implement.

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DISCLAIMER NOTICE

JACKSON PLANT DAM
NH 00121

MERRIMACK RIVER BASIN
NASHUA, NEW HAMPSHIRE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

Identification No.:	NH 00121
NHWRB No.:	165.02
Name of Dam:	JACKSON PLANT DAM
City:	Nashua
County and State:	Hillsborough County, New Hampshire
Stream:	Nashua River
Date of Inspection:	October 31, 1978

BRIEF ASSESSMENT

The Jackson Plant Dam is a 33 foot high gravity concrete and gravity stone masonry dam capped with concrete. The total length of the dam, including spillway and forebay access for the gated openings, is approximately 400 feet. The only functioning outlet work is an ice chute through the dam which acts as an 8 foot long, sharp-crested weir with a crest elevation 0.8 feet below the spillway. The chute becomes a 3.3 foot by 8 foot slot when water reaches the bottom of the forebay slab. When the water is more than 3.2 feet above the spillway, water also flows into the ice chute over the top of the forebay slab. The dam was completed in 1920 and was built to generate power for the Jackson Mills which had a power plant where a restaurant presently exists. The lower cocktail lounge on the forebay slab level is very flood prone. The dam is presently owned by Sanders Associates of Nashua, N.H.

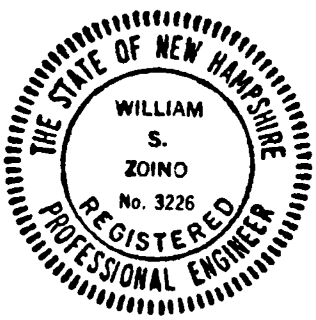
The dam lies on the Nashua River and, at present, serves no readily identifiable purpose. The drainage area of the structure is 529 square miles of which 117 square miles of drainage is diverted for use by the Metropolitan District Commission and the city of Worcester, MA. This yields a net drainage area of 412 square miles. The dam's maximum impoundment of 600 acre-feet and height of less than 40 feet places the dam in the SMALL size category. In the event of a dam failure, considerable property damage would result but little or no loss of life is expected. Because of this the dam rates a SIGNIFICANT hazard potential classification.

Based on the size and hazard potential classifications and in accordance with the Corps' guidelines, the Test Flood (TF) is between the 100-year flood and one half of the Probable Maximum Flood (PMF).

The selected inflow of 20,180 cfs, corresponding to the 100-year inflow, is appropriate because the hazard potential classification falls on the low side of the SIGNIFICANT classification. Under this flow the peak elevation of the flow would be 9.7 feet above the spillway crest, which is 1.7 feet below the tops of the abutments.

The dam is in FAIR condition at the present time. It is recommended that the owner retain the services of a registered professional engineer to supervise the repair or rehabilitation of the ice chute and waste gates, to investigate the practicality of rehabilitating the sluice gates, and to inspect the stone masonry spillway during a period of low flow and implement the findings. Recommended remedial operations include repair of the right abutment, removal and relaying of slope revetment on the downstream right bank, repair of the left abutment, repair of the left wall in the forebay, a program of annual technical inspections of the dam, and a development of a formal warning system to alert downstream people in case of emergency.

The recommendations and improvements outlined above should be implemented within one year of receipt of the report by the owner.



William S. Zoino
N.H. Registration 3226

Nicholas A. Campagna, Jr.
California Registration 21006

PREFACE

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

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

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

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

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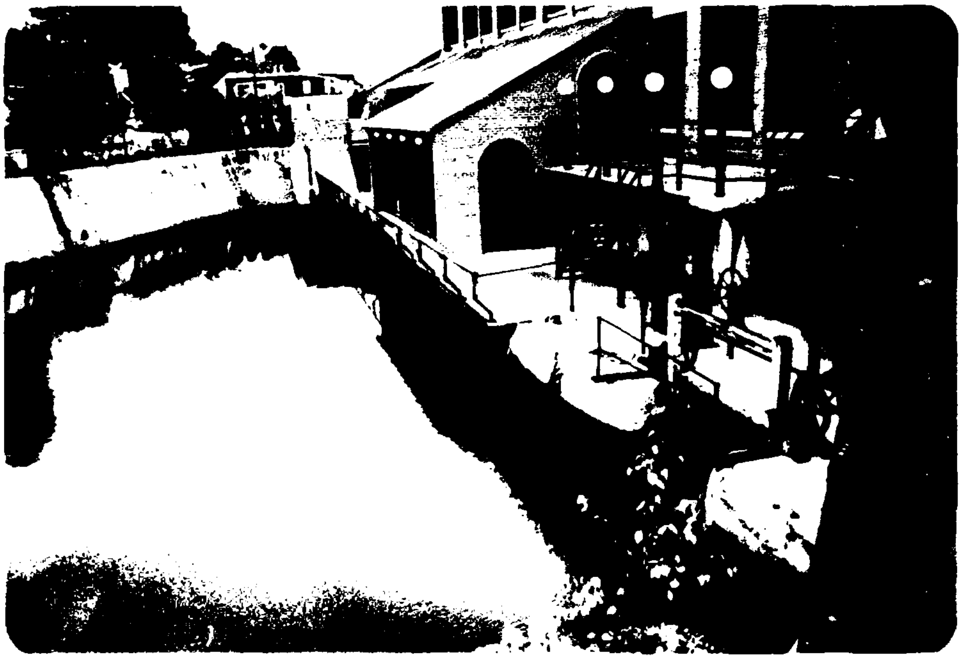
Overview of spillway from pier separating spillway and powerhouse



Overview of restaurant (formerly powerhouse) from pier

Overview of dam from left side upstream

Overview of spillway from downstream left side

The two intermediate concrete piers which divide the intakes into three bays are faced with steel channels. These piers exhibit erosion and spalling which is attributed to ice damage and moisture intrusion from alternate freeze and thaw cycles. Inclined steel trash racks supported on steel framed outriggers, which are rusted, are located in front of all sluice gate openings.

The center line of the waste gate is located approximately 15 feet to the right of the center line of the last sluice gate. A pedestal mounted bull wheel 3.5 feet in diameter which was power driven and operated this waste gate is located within the building and drives a shaft which penetrates through the wall. A similar pedestal-mounted bull wheel connects to this shaft on the forebay platform. The shaft has been removed from the exterior wall face to the exterior bull wheel. The shafting lined up with a double pinion gearing system which operated the waste gate with two rising stems. This power drive system has been removed. This gate cannot be observed since it is submerged. It is estimated that the invert of this gated opening is approximately 17 to 18 feet below the spillway crest. The concrete in front of this gate is severely deteriorated from 12 inches above the water line to as far as can be observed below water. The depth of this erosion is in excess of 6 inches. Exposed reinforcing steel is oxidized and has expanded. This erosion is attributed to ice damage and moisture intrusion from alternate freeze and thaw cycles. A chain is fastened to the concrete facing, its purpose being unknown.

An additional sluice-gated structure with steel guides is located to the right of the aforementioned gated structure and is identified as an ice chute. This structure is in extremely poor condition. The eight-foot wide timber sluice was operated by means of two hand wheels connected to shafted worm gears which actuated a rack and spindle gear. At the time of inspection the top of the gate was submerged in excess of one foot. The ice chute outlet skews back from the face of the forebay platform to the corner of the right end of the building foundation.

With the exception of spalling of a construction joint in the right building foundation wall adjacent to the ice chute outlet channel, the wall is in good condition. A vertical construction joint, 4 inches wide and one inch deep, has opened and spalled for approximately 10 feet.

Access was limited to the most downstream turbine bay, the other two bays being sealed off in the cocktail lounge. Visual observations revealed that there was standing water in the bay, but there was no visual or audible evidence of seepage. Because of prior modifications within the bay, it could not be readily determined whether the downstream tail water outlet is intact or has been filled. The timber sluice gates, as observed from within the turbine bay, appear to be in good condition.

The sluice gates were designed to be motor operated in tandem from within the building. It could not be determined whether all twelve gates operated from a single shaft or in groups of 4 for each turbine bay. The connecting shafts have been cut off at their bushings. Each gate operator is equipped with a clutch for independent operation. The geared drive system rotates a shaft which penetrates the exterior wall; the shaft has been connected to a second gearing system which actuates the gate's rising stem. The stems are enclosed within pipe stanchions which penetrate through the concrete platform which is an extension of the first floor. There are gate dials for monitoring the opening of each gate which read from 0 to 14. The pressure relief gate mechanisms are fabricated in a similar manner. In general, the visible mechanical assemblies of 11 gates appear to be in good condition. The mechanism of the twelfth gate was dismantled during erection of the cocktail lounge addition. There is no evidence of maintenance. All gears are completely refinished with paint and appear to be bound. All the rising stems are bound. It is apparent that these gates have not been in operation since conversion of the building to commercial purposes. In the event that the mechanical equipment was rehabilitated, it is doubtful that these gates could be operated by means of existing hand wheels because of the amount of friction.

Observations have revealed that horizontal construction joints in the concrete facing have opened. In one instance, vegetation is flourishing at one of these joints on the forebay side of the abutment. The top of this structure has a considerable degree of spalling. The remains of a rotted timber fishway sluice gate is located on the upstream face of this structure adjacent to the spillway. A 10-inch diameter tree stump is located within the gate opening. The tree stump is cut off approximately 12 inches above the spillway crest elevation. The erosion and spalling on this structure is attributed to poor concrete or lack of quality control with moisture intrusion and subsequent alternating freeze and thaw cycles.

A secondary training wall is located at the downstream end of the "spill-over" wall at its terminus with the building foundation. This wall, which is approximately 50 feet long, extends into the outlet channel in line with the upstream building foundation. The outlet of the gated ice chute and waste gate through the building is located immediately adjacent to this wall. This wall is severely spalled and eroded. Spalling up to 2 inches in depth is prevalent over its top surface and upstream face. The end of the wall is eroded. Its downstream face has random horizontal cracks with efflorescence and exudation. This surface spalling is attributed to moisture intrusion and alternate freeze and thaw cycles, and the erosion is attributed to ice damage and cavitation. The ice chute outlet through the building foundation has been subjected to severe erosion. Reinforcing steel is exposed over a vertical height of approximately 10 feet. Surface spalls up to 6 inches in depth are prevalent in the outlet walls. This erosion and spalling is attributed to cavitation and ice damage.

(4) Building Structure

The building structure, with the exception of erosion within the ice chute and spalling of a limited portion of the first floor platform, is in good condition. These defects are described further in this section of the report.

The concrete-capped stone gravity section of the spillway could not be readily observed, since flow over the spillway prevented good observation of the spillway.

(3) Left Abutment

This structure is divided into two specific components. The first consists of a wood plank "decked-over" structure with a concrete training wall normal to the left end of the spillway. This component is approximately 11 feet above the spillway crest elevation and is used as a restaurant promenade. The second component consists of a dual level concrete apron and a "spill-over" wall. The first apron is approximately 4 feet below the spillway crest; the second being approximately 4 feet lower.

Observations of the training wall located to the left of the concrete aprons have revealed that there are a series of horizontal open joints which can be attributed to poor placement of concrete. There is considerable random cracking over its entire surface with associated efflorescence. Its downstream end was reconstructed. Improper bonding has resulted in open horizontal and vertical joints which have opened on the order of one inch. Spalling around these joints is up to 4 inches wide and 1 inch deep. The base of the lower end of this wall has eroded from cavitation.

The downstream extension of the "spill-over" wall between the end of the upper training wall and the building foundation is spalled over 50% of its top surface and its face. This is attributed to moisture intrusion and alternate freeze and thaw cycles. The upper section of this wall could not be observed because of discharge over the spillway.

The vertical faces, which face the impoundment pool, of the main portion of the abutment have spalled over approximately 5% of its surface area. This is attributed to moisture intrusion from alternate freeze and thaw cycles. These faces have numerous horizontal and random cracks with a high degree of efflorescence.

SECTION 3 - VISUAL OBSERVATION

3.1 Findings

(a) General

The Jackson Plant Dam is in FAIR condition at the present time. This structure requires repair of the existing waste gates and ice chute. It does not appear practical to restore the existing sluice gates to serviceability.

(b) Dam

(1) Right Abutment

The vertical faces of this structure have spalled over 75% of their surface area to depths of 4 inches. There is considerable patterned horizontal cracking with associated efflorescence. The spalling and cracking reveals a stone masonry structure which has been faced and capped with concrete. The spalling and cracking is attributed to moisture intrusion and alternate freeze and thaw cycles. Vegetation is growing through open joints on the downstream leg of this abutment.

The voids of the first 75 foot length of the revetment downstream of the right abutment are filled with concrete grout. This revetment is in good condition without any evidence of settlement or undermining. Minor erosion of the grout has occurred at the channel bed. Downstream of the grouted revetment, a revetment approximately 150 feet long is set up with open joints. This revetment has unravelled for a distance of approximately 75 feet. This unravelling is the result of the lack of control of surface drainage which has undermined the slope. The continuation of the revetment along the right bank, grouted and open jointed, is in good condition.

(2) Spillway

The concrete gravity portion of the spillway adjacent to the right abutment has been subjected to considerable surface erosion on its downstream face. This erosion may be attributed to cavitation and ice damage.

SECTION 2 - ENGINEERING DATA

2.1 Design Records

The design of the dam is quite simple and incorporates no unusual features except for the addition of the power house. Design drawings of the planned power house at the dam were available, and the pertinent drawings are included in Appendix B.

2.2 Construction Records

No construction records are available for the dam.

2.3 Operational Records

There are no operational records for the dam. At present the dam is not operated but exists in an uncontrolled manner.

2.4 Evaluation of Data

(a) Availability

The lack of design drawings and calculations of the spillway and calculations for the power house is a significant shortcoming. An overall unsatisfactory assessment for availability is, therefore, warranted.

(b) Adequacy

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

(c) Validity

Since the observations of the inspection team generally confirm the information contained in the drawings of the power house, with modification, a satisfactory evaluation for validity is indicated. The extent of the differences between the drawings of the power house and the field observations could not be accurately determined.

(e) Dam

(1) Type: Concrete gravity and gravity stone masonry

(2) Length: 400 feet ± including forebay section of old power house

(3) Height: 33 feet

(4) Top Width: Varies, spillway approximately 2 feet

(5) Cutoff, grout curtain: Unknown

(f) Spillway

(1) Type: Gravity concrete and stone masonry

(2) Length of Weir: 180 feet

(3) Crest Elevation: 115.6

(4) U/S Channel: Width of river

(5) D/S Channel: Width of River

(g) Regulatory Outlets

See item 1.3 (b) (1).

The peak flow at the gage in 42 years of record is 20,900 cfs on March 20, 1936.

(3) Spillway capacity at maximum pool elevation:

24,720 cfs at El. 127.0

(4) Gated capacity at recreational pool elevation:

19 cfs at El. 115.6 (ice chute only)

(5) Gated capacity at maximum pool elevation:

990 cfs at El. 127.0 (ice chute only)

(6) Total capacity at maximum pool elevation:

25,700 cfs at El. 127.0

(c) Elevation (ft. above MSL)

(1) Top of Dam: El. 127.0

(2) Maximum pool: El. 127.0

(3) Recreational pool: El. 115.6

(4) Spillway crest: El. 115.6

(5) Weir elevation of ice chute: El. 114.8

(6) Streambed at low point: El. 94 ±

(7) Maximum tailwater: Unknown

(d) Reservoir

(1) Length of pool - recreational: Approx. 3 miles
- maximum: Approx. 4 miles

(2) Storage - recreational: 150 acre-ft.
- maximum: 600 acre-ft.

(3) Reservoir surface - recreational pool: 40 acres
- maximum pool: 50 acres ±

(i) Normal Operational Procedure

At the present time no operational procedure is in effect at the dam. Water flows over the spillway and ice chute in an uncontrolled manner.

1.3 Pertinent Data

(a) Drainage Area

The total drainage area of the dam is 529 square miles. Of this area, 117 square miles of drainage is diverted by the Metropolitan District Commission and the City of Worcester, Massachusetts. This leaves a net drainage area for the dam of 412 square miles.

(b) Discharge at Damsite

(1) Outlet Works

Most of the outlet works at the dam are no longer operational. There are 12 sluice gates leading to the former power house, a waste gate of undetermined size, an 8 foot wide ice chute, and a 30 inch pipe leading from the left training wall. At the present time the 12 sluice gates and the waste gate are not operational. Water flows over the ice chute structure which has a top elevation approximately 0.8 feet below the top of the spillway. The 30 inch pipe supplies Sanders Associates with an emergency fire-fighting water supply at their plant downstream.

(2) Maximum Flood

There are no detailed records of the maximum flows at the Jackson Plant Dam site. A drawing obtained from the New Hampshire Water Resources Board (NHWRB) files indicates that substantial flooding both above and below the dam occurred during the 1936 flood. The drawing indicates that the flood waters were over the adjacent Canal Street near the dam site. A USGS gage (01096500) on the Nashua River at East Pepperell, Massachusetts, is well upstream of Nashua. This gage has a drainage area of 433 square miles, compared to 529 square miles (not diverted) at the dam.

(d) Hazard Potential Classification

A failure of Jackson Plant Dam would result in significant property damage to the factory located downstream of the dam while presenting only a minimal risk of loss of life. For these reasons, a hazard potential classification of SIGNIFICANT is warranted.

(e) Ownership

The dam is owned by Industrial Realty Corporation which is a division of Sanders Associates of Nashua, N.H. Corporate Headquarters for Sanders Associates are located on Daniel Webster Highway, South; Nashua, N.H. 03060.

(f) Operator

The dam is officially operated by Sanders Associates although no operation of the dam is presently being performed. Mr. Thomas McNulty of Sanders Associates is the contact concerning operation of the dam, and he can be reached by telephone at 603-885-2111 and at 95 Canal Street, Nashua, N.H. 03061.

(g) Purpose of Dam

At present, the dam serves no readily identifiable purpose. It was once used to generate power for the Jackson Mills by means of generators located in the sub-basement. The generators have been disconnected, and the former power house is now a restaurant and cocktail lounge.

(h) Design and Construction History

The available records concerning the design and construction history of the dam are very sketchy and do not provide much data, some of which is conflicting. The 1936 Inventory sheet of the New Hampshire Water Resources Board shows the completion of the dam in 1907. However, design drawings for the power house were prepared in 1919 indicating that the completion of the structure could not have been before 1920. It is possible that some type of dam existed at the site prior to the construction of the power house. Apparently, at some later date, but before 1939, the spillway was extended approximately 30 feet at its southern (right) end. This is the concrete portion of the spillway. The power house has not been used since Sanders Associates acquired the property. The restaurant is a recent addition being constructed during the last 2 years.

The former generating plant, which is 121.5 feet long and 36.0 feet wide, has been converted into a restaurant and cocktail lounge identified as the Chart House. The building once housed three turbines in a sub-basement. Each turbine bay was approximately 35 feet in length and was serviced by four timber sluice gates approximately 7 feet square and a 15 inch by 24 inch pressure relief gate. Full height concrete sluiceway dividing walls, approximately 14 feet long, frame into the upstream foundation wall.

The sluice and pressure relief gates are operated by wheel mechanisms located in the basement level adjacent to the building wall. The gates themselves are housed outside the foundation wall below the forebay platform. The sluice gate rising stems are enclosed within pipe stanchions which extend above a concrete platform located at the first floor elevation. Inclined steel grate trash racks are set in front of the 12 sluice gate openings. In addition to the sluice gates, two gated structures are located immediately upstream of the last turbine chamber. These structures consist of a timber waste gate equipped with hand wheel operating mechanisms and an ice chute 8 feet wide. The width of the waste gate cannot be determined. A timber platform approximately 2.5 feet wide with a chain link fence is cantilevered in front of and along the forebay platform up to the waste gate.

The left bank is retained by a concrete-faced stone masonry wall approximately 235 feet long within the forebay area and a dry stone masonry wall extending upstream for approximately 175 feet. These walls support a railroad embankment. A gated structure is located approximately 150 feet upstream of the downstream end of the concrete faced wall. Available records indicate that the outlet consists of a 30 inch pipe. A timber log boom extends from the upper left end of the left abutment to the left bank. The purpose of the log boom is to prevent debris from floating into the forebay area.

(c) Size Classification

The dam's maximum impoundment of 600 acre-feet and height of less than 40 feet places the dam in the SMALL size category as defined by the "Recommended Guidelines."

1.2 Description of Project

(a) Location

Jackson Plant Dam lies on the Nashua River in Nashua, N.H. The dam lies approximately 700 feet downstream from the crossing of U.S. Route 3 over the Nashua River. The dam is readily accessible from Route 101A which intersects Route 3 just north of the Nashua River. The portion of USGS Nashua North, N.H. quadrangle presented previously shows this locus. Figure 1 of Appendix B presents a detail of the site developed from the inspection visit and the map.

(b) Description of Dam and Appurtenances

The dam and appurtenances consist of a stone masonry spillway with a concrete cap and a concrete extension, concrete-faced stone gravity abutments, and a former power generating station which has been converted into a restaurant and cocktail lounge which houses fourteen gated openings. The forebay to the former power station is confined by a concrete-faced retaining wall which forms the left bank. The dam, including the forebay access for the gated openings, is approximately 400 feet long. The spillway is approximately 180 feet long and consists of a gravity concrete section of approximately 30 foot length with the remainder being a gravity stone masonry section capped with concrete.

The right abutment is a stone masonry structure which has been capped with concrete. The structure is laid out in the form of a splayed "U" and has a base width of approximately 30 feet normal to the axis of the spillway. The upstream leg is approximately 10 feet long and splays back into the bank at about a 45^{o} angle. The downstream leg of the abutment is laid out in an arc with a chord length of about 25 feet. The abutment splays into the embankment at an angle of approximately 30^{o}. A revetted slope, consisting of concrete-grouted and dry stone masonry, originates at the face of the right abutment and extends downstream for approximately 500 feet. The slope of the revetment is about 2 horizontal to 1 vertical.

The left spillway abutment is a concrete-faced stone structure which ties into the building foundations downstream of the spillway. The structure is trapezoidally shaped and is approximately 38 feet wide with an average length of about 65 feet. The abutment was once used as a fish weir and tunneled fishway in the past.

PHASE I INSPECTION REPORT

JACKSON PLANT 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. Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZD) has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed was issued to GZD under a letter of November 28, 1978 from Colonel Max B. Scheider, Corps of Engineers. Contract No. DACW 33-79-C-0013 has been assigned by the Corps of Engineers for this work.

(b) Purpose

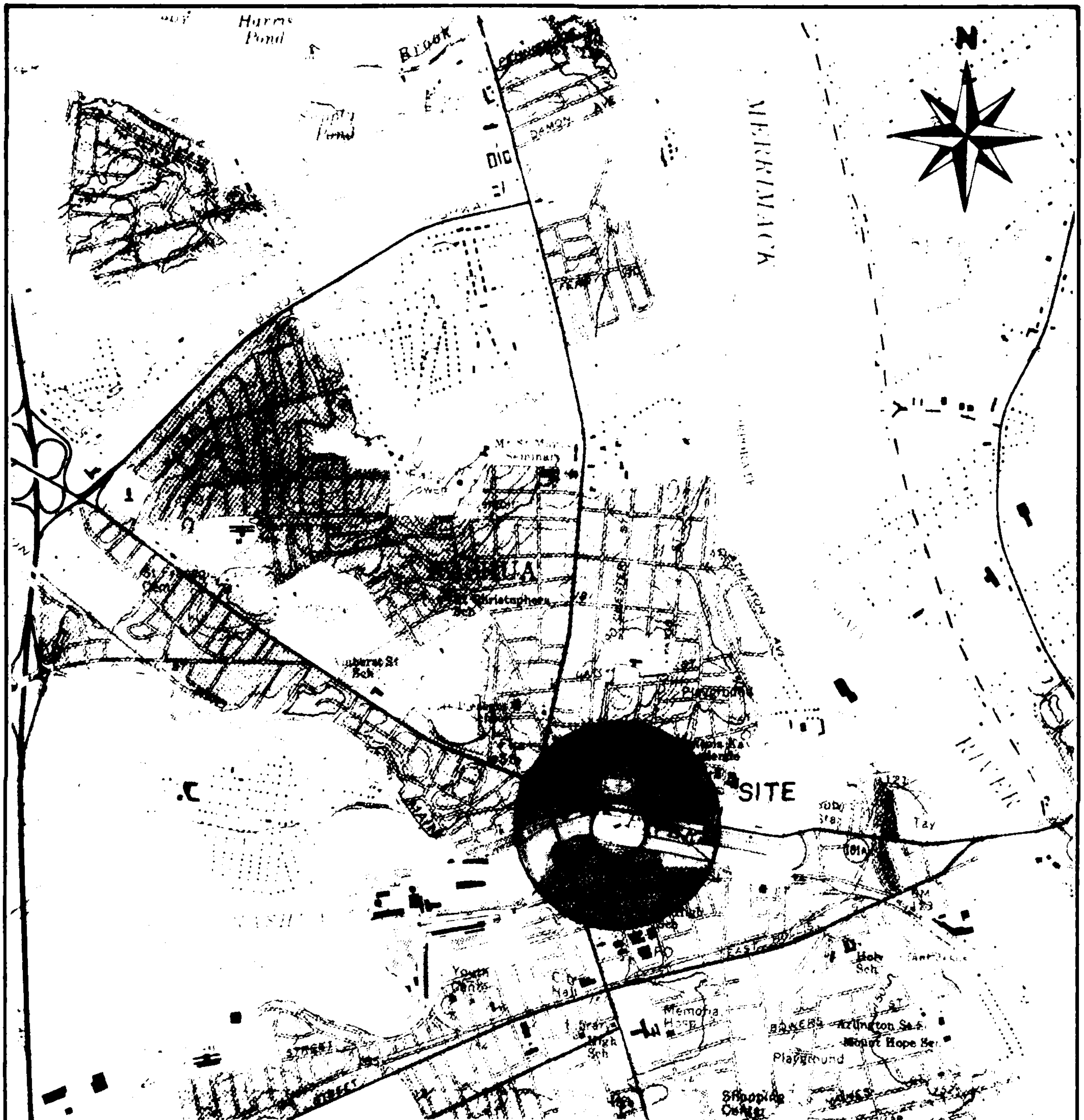
(1) Perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests.

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

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

(c) Scope

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



- SCALE -

0 1000 2000 4000 FT

FROM: USGS NASHUA NORTH, N.H. QUADRANGLE MAP

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCUS PLAN

JACKSON PLANT DAM — NEW HAMPSHIRE

FILE No. 2201

SCALE AS NOTED

DATE OCTOBER 1978

The adjacent waste gate outlet intercepts the ice chute outlet at the upstream face of the building wall. The outlet extends along the inside of the upstream building wall to its outlet to the left bank of the river.

The timber frame gate for the ice chute is severely rotted and not operable. The concrete supporting the gate guides is severely eroded. The erosion at the face and behind the guides is as much as 8 inches and occurs from the underside of the forebay platform for an estimated vertical distance of 9 to 10 feet below the platform level. In some instances this erosion extends 3 to 4 feet along the side walls. At the time of the inspection it was observed that the gate guides are in an extremely poor condition because of advanced erosion of the concrete interface. A large volume of water is seeping around the gate guides at an extremely high velocity. A high degree of erosion, up to 12 inches in depth, was also observed on both side walls at the first platform level where the chute skews to connect with the sealed waste gate channel.

The channel bed of the forebay has silted up in front of all the sluice gates. Within the trash racks the silting varies from 5.2 feet at the downstream end of the building to 3.2 feet adjacent to the waste gate. The thickness of silting outside the trash racks varies from 8.0 feet at the downstream end of the building to approximately 5.0 feet adjacent to the waste gate.

The forebay platform is 13.4 feet wide and extends over the entire length of the left side of the building. The platform was planned to be uniform in width but the geometry has changed because of expansion of the cocktail lounge. There is an opening in this platform which is located adjacent to the building wall opposite the ice chute inlet. Surface spalls have been repaired and in general, this portion of the structure is in good condition. The wood planked platform which is supported in front of the concrete forebay and the chain link fence enclosure are in good condition.

The exterior concrete face of the building wall adjacent to the forebay platform has much surface staining, cracks, and efflorescence which is attributed to seepage through the first floor platform. The walls adjacent to the platform opening opposite the ice chute are highly exudated. The underside of the first floor platform adjacent to the forebay platform opening has been subjected to a high degree of spalling for a distance of approximately 20 feet. Surface spalls on the underside of this slab are as much as 2 inches in depth over 10% of the underside of the slab. This spalling is attributed to moisture intrusion and alternate freeze and thaw cycles.

(5) Left End Wall

The concrete faced stone masonry wall supporting the left bank is in very poor condition. Severe concrete spalling has occurred over approximately two-thirds of its surface area. The remaining portion of its surface has been subjected to extensive random cracking and efflorescence. The spalls are so intense that in some areas the entire vertical height for lengths up to 20 to 30 feet are completely spalled. It is also evident that gunite repairs were attempted at the water line. These repairs have deteriorated. The spalling is attributed to poor quality control of concrete subjected to moisture intrusion and alternate freeze and thaw cycles. The upstream dry stone masonry wall is in poor condition because of unravelling in its mid location.

The sluice gate structure, consisting of a wheel operated rising stem gate which is located on the left bank, is in very poor condition. This structure is completely enclosed by a locked 8 foot high chain link fence. The concrete has severely deteriorated, resulting in bulging, exposed reinforcing steel, a high degree of spalling, cracks up to ¼ inch wide, extensive efflorescence, and exudation. The high degree of concrete deterioration is attributed to poor quality control of concrete which has been subjected to moisture intrusion and alternate freeze and thaw cycles.

3.2 Evaluation

The Jackson Plant Dam is rated in FAIR condition. This rating is based on the amount of concrete deterioration observed and the condition of the gate structures. Most of the major structural components of the dam could be examined, however, the condition of the stone masonry spillway and the submerged sluice gate could not be accurately determined since they were not visible.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

At present no operational procedures are performed at the dam. None of the sluice gates or waste gate and ice chute gate are operable. Therefore, water presently flows over the spillway and ice chute gate in an uncontrolled manner. The pipe leading through the left training wall is still operable and is used for back up fire protection by Sanders Associates.

4.2 Maintenance of Dam

No maintenance of the dam is performed.

4.3 Maintenance of Operating Facilities

The only operable facility at present is the 30 inch line supplying Sanders Associates with backup fire protection. The general condition of the intake structure is poor although it is operated on a weekly basis.

4.4 Description of Any Warning System in Effect

No warning system is in effect for this dam.

4.5 Evaluation

The dam's present FAIR condition is a direct result of the lack of maintenance of the dam. Maintenance of the dam and its facilities should be improved.

SECTION 5 - HYDRAULICS/HYDROLOGY

5.1 Evaluation of Features

(a) Design Data

Data sources available for Jackson Plant Dam include prior inventory reports, inspection reports, and an Anderson-Nichols Company (ANCO) Flood Insurance Study (FIS). The New Hampshire Water Control Commissions' "Data on Dams in New Hampshire" (April 10, 1939); the New Hampshire Water Resources Board's (NHWRB) "Inventory of Dams and Water Power Developments" (August 25, 1936) and "Water Power Developments in New Hampshire" (January 29, 1948); and the Public Service Commission of New Hampshire's "Dam Record" (August 31, 1936) and "Dams in New Hampshire" (January 29, 1919) provide much of the basic data for the dam. The ANCO 1977 FIS covers this portion of the river and included 10, 50, 100, and 500-year peak inflows, cross-section data at various points on the Nashua River (including the dam and the bridges downstream); and HEC-2 runs for the 10, 50, 100, and 500-year flows.

Additional information is contained in the inspection reports in the files of the NHWRB and in a letter from Sanders Associates to the NHWRB. The 1919 plans for construction of the power house are also available.

(b) Experience Data

There are no official records of flow or stage at Jackson Plant Dam. A USGS gage (10196500) on the Nashua River at East Pepperell, Massachusetts, is well upstream of Nashua. This gage has a drainage area of 433 square miles, compared to 529 square miles at the dam. The peak flow at the gage in 42 years of record is 20,900 cfs on March 20, 1936.

(c) Visual Observations

The Jackson Plant Dam in Nashua, New Hampshire is a concrete run-of-the-river dam on the Nashua River about 1000 feet downstream of the Main Street Bridge. The spillway has an overall length of 180 feet at a crest elevation of 115.6 feet above Mean Sea Level. The stream bed is at elevation 94.0 feet, making the spillway about 21.6 feet high.

At the time of the inspection, the water level was flowing about three-tenths of a foot over the spillway crest. Little storage capacity is available in this run-of-the-river reservoir, given the shape of the valley immediately upstream of the dam.

The left and right abutments of the dam are concrete structures and extend about 11.4 feet above the spillway. The right abutment structure extends some 20 feet and ties into the natural ground, which is flat for about 20 feet and then climbs a rather steep embankment. The left abutment structure extends about 40 feet and ties into a restaurant which now occupies the building which was once a power generating station. This restaurant extends about 120 feet, and ties into the left bank which slopes from 11.4 to 14.4 feet above the spillway crest in 60 feet. The bank is level for 35 feet, and then climbs a gradual embankment. A schematic elevation of the dam is included in Appendix D.

The restaurant is a brick building with two levels. Water levels greater than 3.2 feet above the spillway would flood the cocktail lounge on the lower level, while the main level is about 11 feet above the spillway. In late January 1979, the water level was 5 inches above the forebay slab (3.6 feet above spillway crest). This flooded the cocktail lounge on the lower level.

The only other outlet presently functioning at the dam is an ice chute through the dam. This ice chute has an 8 foot wide submerged timber gate which acts as a sharp-crested weir with crest elevation eight-tenths of a foot below the spillway. The gate is no longer operable. The chute becomes a 3.3 foot by 8 foot slot when water reaches the bottom of the forebay slab 2.5 feet above the spillway. When the water surface is more than 3.2 feet above the spillway, water also flows into the ice chute over the top of the forebay slab.

There are 12 gates to the power house which are no longer operable. There is also a gate leading to a 30" line off the left approach channel to the dam. A waste gate next to the ice chute is not operable, and its dimensions are not unknown.

The channel of the river downstream of the dam is large (about 100 feet wide) and granite-lined, with high banks on both sides, down to a B & M Railroad bridge some 1,260 feet downstream. The channel bottom under this bridge is at 88.5 feet MSL, the low chord at 112.6 feet and the top of bridge at 124.5 feet.

The channel downstream of this bridge is still about 100 feet wide and granite lined. The right bank is a high slope, the left bank is an 18 foot wall with the top about 30 feet above the channel invert. To the left of this wall is a 35 foot wide flat area adjoining a large factory which parallels the channel for most of the 1650 feet to the next bridge.

This bridge for Route 101A is a stone masonry structure with two arches, each about 80 feet wide. The channel invert is at 86.5 feet MSL, the low chord at 115.0, and the top of the road at 120.0. To the right is a row of houses with ground floors at about the same level as the bridge top. There is no significant development below this bridge in the 3800 feet to the Nashua's confluence with the Merrimack River. Another B & M railroad bridge crosses the Nashua some 2800 feet downstream of Route 101A, but its low chord is 30 feet above the channel.

(d) Overtopping Potential

The hydrologic conditions of interest in this Phase I investigation are those required to assess the dam's overtopping potential and its ability to safely allow an appropriately large flood to pass. This requires using the discharge and storage characteristics of the structure to evaluate the impact of an appropriately sized Test Flood. None of the original hydraulic and hydrologic design records are available for use in this study.

Guidelines for establishing a recommended Test Flood based on the size and hazard classification of a dam are specified in the "Recommended Guidelines" of the Corps of Engineers. The impoundment of less than 1,000 acre feet and the height of less than 40 feet classify this dam as a SMALL structure.

The appropriate hazard classification for this dam is SIGNIFICANT because of the possibility of significant economic losses downstream in the event of dam failure. The possibility of incremental flooding at the factory downstream, the Route 101A bridge, and the houses near the bridge, combined with the change of significant damage to the restaurant on the left side of the dam make it likely that serious economic loss would result from failure of the dam. While increase in flooding caused by failure would pose a threat to property, there would be only minimal threat to lives.

As shown in Table 3 of the Corps of Engineers' "Recommended Guidelines," the appropriate Test Flood for a dam classified as SMALL in size with a SIGNIFICANT hazard potential would be between the 100-year flow and 1/2 of the probable maximum flood (PMF). ANCO's FIS gives a 100-year flow of 20,180 cfs and a 500-year flow of 34,500 cfs. The 1/2 PMF can be considered equivalent to the 500-year flow. Since the hazard classification is on the low side of SIGNIFICANT, the 100-year flow of 20,180 is appropriate for use as the Test Flood for this dam. For this run-of-the-river dam there is not sufficient storage capacity available behind the dam to warrant a surcharge storage correction of the Test Flood inflow. The peak elevation created by the flow of 20,180 cfs would be 125.3 feet MSL, 9.7 feet above the spillway crest, and 1.7 feet below the tops of the abutments.

5.2 Hydraulic/Hydrologic Evaluation

The Test Flood analysis for Jackson Plant Dam indicates that the dam would not be overtopped by the Test Flood. Furthermore, the hydraulic analysis of this low head, run-of-the-river situation indicates that high tailwaters downstream will accompany high flow condition so that downstream flooding would not be greatly affected by failure of the dam. It therefore appears that the existing spillway is adequate within the context of this Phase I report.

5.3 Downstream Dam Failure Hazard Estimates

The peak outflow that would result from the failure of Jackson Plant Dam is estimated using the procedure suggested in the Corps of Engineers New England Division's April 1978 "Rule of Thumb Guidelines for Estimating Downstream Dam Failure Hydrographs," as clarified in a December 7, 1978 meeting at the Corps' Waltham office. Failure is assumed to occur with the water surface elevation at the top of the abutments, 11.4 feet above the spillway crest (elevation 127.0).

The effect of the dam failure depends greatly on the downstream water level, which is controlled by backwater from the Merrimack River. In the analysis it is assumed that the Merrimack River is flooding in conjunction with the Nashua. This is reasonable, since the size of the Nashua's drainage basin makes it likely that a storm producing large flows at its mouth would be regional, also producing large flows in the Merrimack.

To determine the normal discharge at the failure stage, refer to the Stage-Discharge curve in Appendix D.

The discharge prior to failure with the water level 11.4 feet above the spillway would be approximately 25,700 cfs. This flow is between the estimated 100-year and 500-year flows. This discharge, combined with high water conditions on the Merrimack, would result in significant flooding downstream and would possibly overtop the Route 101A bridge. The tailwater prior to failure would be approximately 5.4 feet above the spillway. The factory on the north bank would experience flooding prior to failure.

Dam failure under these conditions would result in only a slight increase in the total flow. With a 70 foot gap opened in the spillway, the increment is estimated to be 1700 cfs or a total flow of 27,400 cfs. This incremental flow would result in less than a one foot rise in downstream flood elevations. Downstream damage to the factory would be incrementally increased because of a greater depth of water, and some flooding could occur in the area of the houses near the 101A bridge.

Perhaps the major potential impact of dam failure is at the dam itself. The restaurant on the left side is a major structure. If this structure failed, the damage to the building would be significant. However, it is unlikely that the restaurant would be occupied when the Nashua River is at high stage, so there is little potential for loss of life.

In the event that the Nashua Basin were to produce a peak discharge on the order of 26,000 cfs without a simultaneous flood developing on the Merrimack, the dam could possibly fail with a much lower tailwater condition. Under this tailwater condition the channel would probably carry the pre-failure flow without damage to the factory or bridge, but when failure occurred the large incremental flow caused by the greater head potential would cause the downstream reaches to rise rapidly resulting in significant damages to the factory from the failure. There is also a slight potential for loss of life at the factory under these conditions.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

(a) Visual Observation

The field investigations revealed no significant displacement and/or distress to warrant the preparation of structural stability calculations based on assumed sectional properties and engineering factors.

(b) Design and Construction Data

No plans or calculations of value to a stability assessment are available for this dam. In particular, no information on the foundation conditions is available.

(c) Operating Records

At present, no operation of the dam is performed.

(d) Post Construction Changes

Major alterations were made to the former power generating building in 1961 when it was converted to commercial use. The extension of the spillway by about 30 feet at the right abutment increased spillway capacity.

(e) Seismic Stability

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, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

(a) Condition

The Jackson Plant Dam is in FAIR condition at the present time. The sluice gates, waste gate, and ice chute gates are not operable. The waste gate is susceptible to a structural failure. The restaurant cocktail lounge at the forebay slab level is very susceptible to floods as evidenced by minor flooding in late January 1979.

(b) Adequacy of Information

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

(c) Urgency

The engineering studies and improvements described herein should be implemented by the owner within one year of receipt of this Phase I Inspection Report.

(d) Need for Additional Investigation

Additional investigations are required as recommended in Paragraph 7.2.

7.2 Recommendations

It is recommended that the owner retain the services of a registered professional engineer to supervise the repair or rebuilding of the ice chute and waste gates, and to investigate the practicality of rehabilitating the sluice gates, and to inspect the stone masonry spillway during a period of low flow and to implement the findings.

7.3 Remedial Measures

The Jackson Plant Dam requires that the remedial measures outlined below be undertaken:

(1) Repair the deteriorated concrete at the right abutment.

(2) Remove and relay slope revetment on downstream right bank including proper control of surface drainage.

(3) Repair the deteriorated concrete at the left abutment.

(4) Repair the deteriorated concrete at the left wall in forebay.

(5) Institute a program of annual technical inspections of the dam.

(6) Develop a formal warning system to alert downstream people in case of emergency.

7.4 Alternatives

There are no meaningful alternatives to these recommendations.

APPENDIX A

VISUAL INSPECTION CHECKLIST

INSPECTION TEAM ORGANIZATION

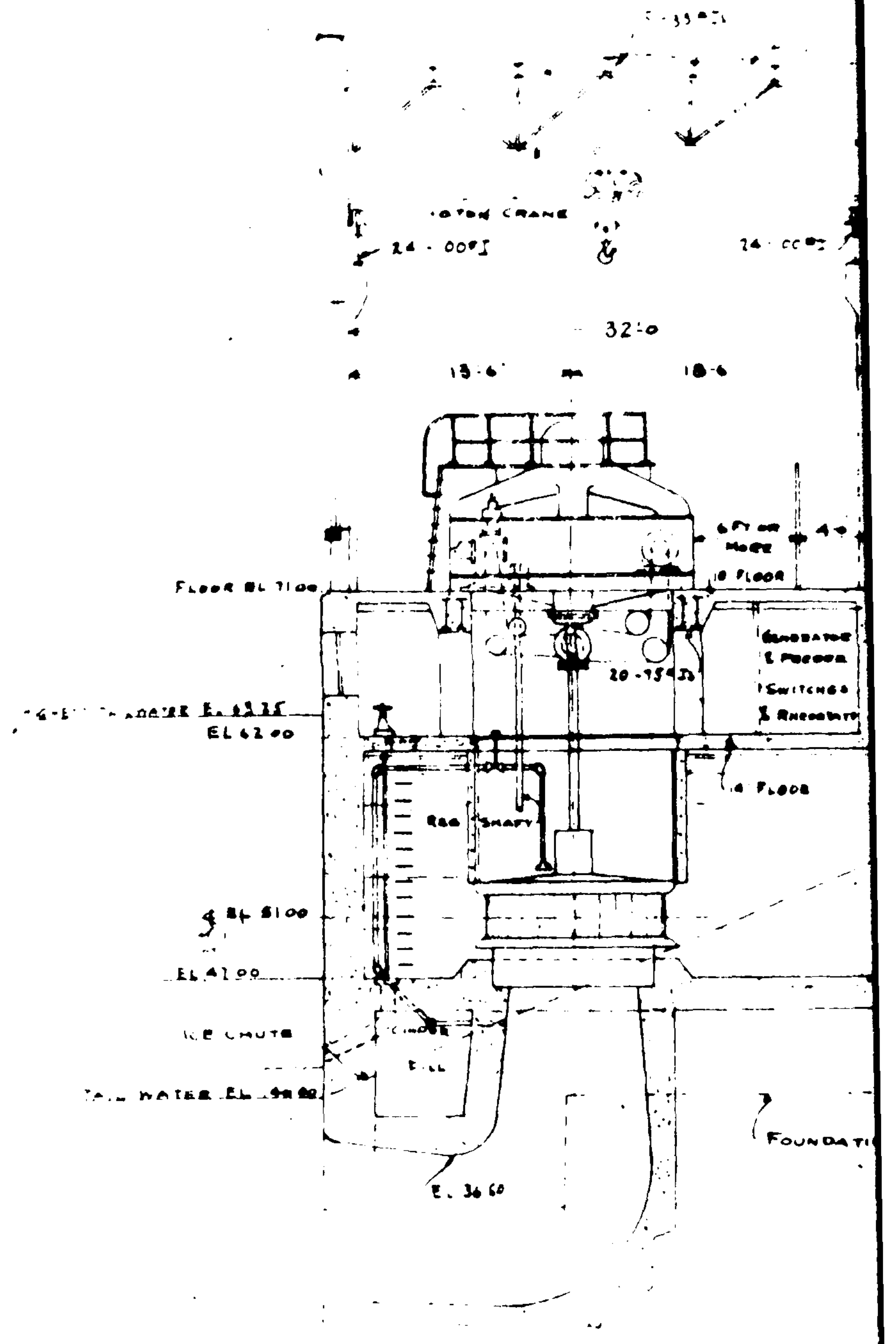
Date: October 31, 1978

NH 00121
JACKSON PLANT DAM
Nashua, New Hampshire
Nashua River
NHWRB 165.02

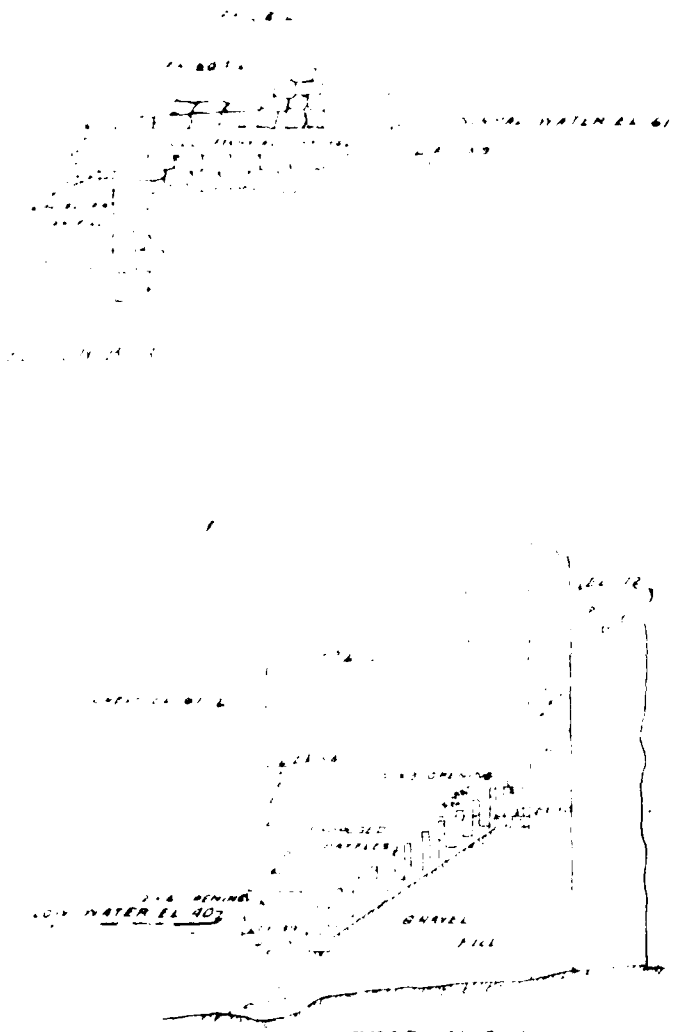
Weather: Clear, 55°F

INSPECTION TEAM

Nicholas Campagna	Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZD	Team Captain
William Zoino	GZD	Foundations
Robert Minutoli	GZD	Soils
Andrew Christo	Andrew Christo Engineers (ACE)	Structural
Paul Razgha	ACE	Concrete
Richard Laramie	Resource Analysis, Inc.	Hydrology



SECTION LOOKING



SECTION A-A

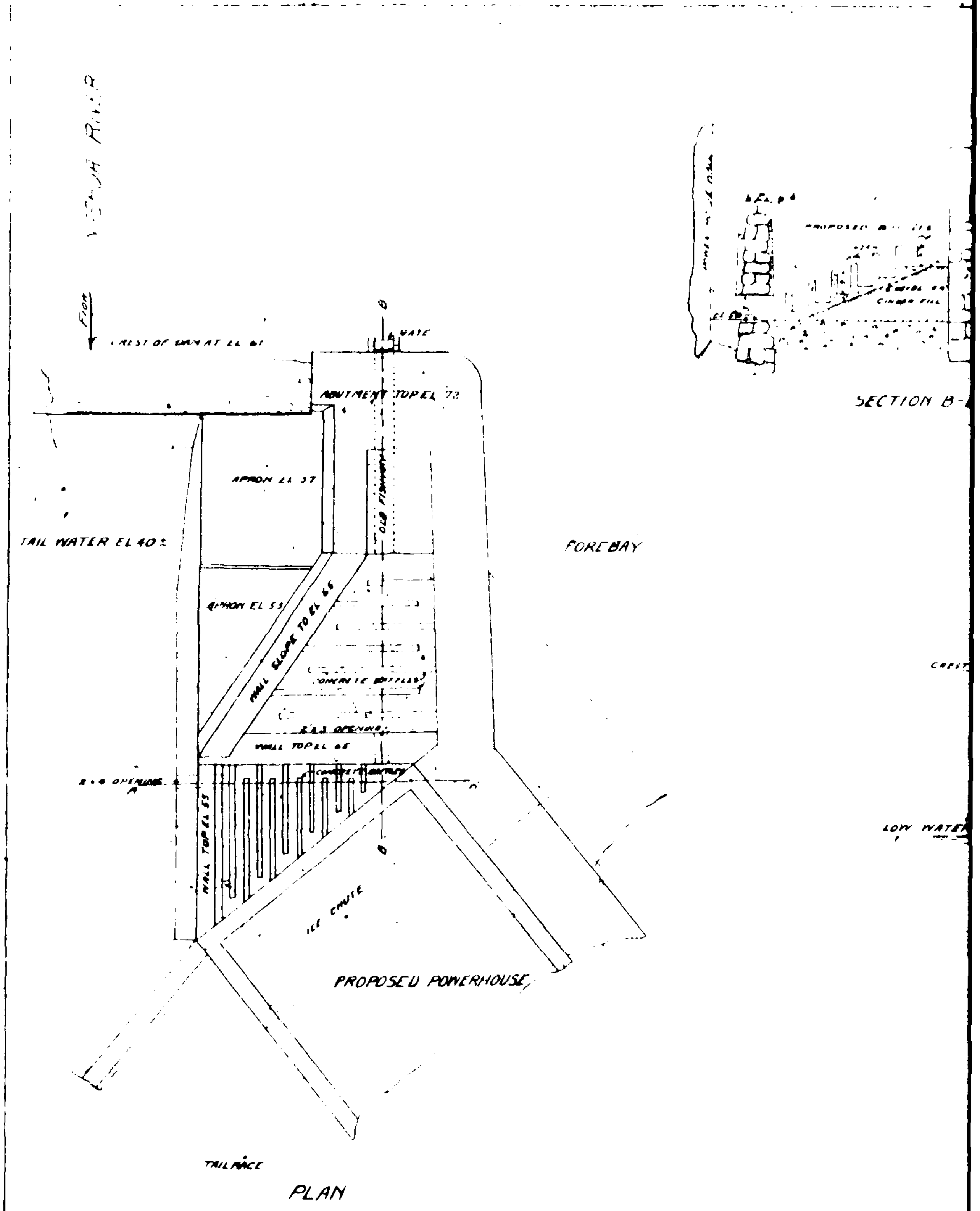
NOTE: DRAWING HAS BEEN REDUCED
SCALES ARE NOT AS SHOWN.

[redacted]

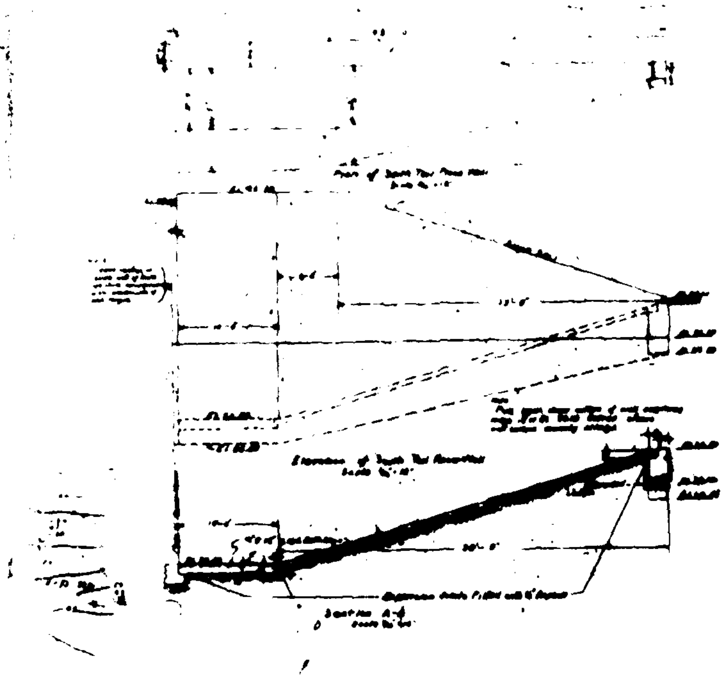
JACKSON MILLS OF THE NASHUA ...
NASHUA N.H.
PROPOSED FISH WAY
SCALE

JOHN A. STEVENS ENGR
MERRIMACK ST. LOWELL MASS

DRAWN BY ENS
TRACED BY
CHECKED BY
REVISED
SHEET No. 30


FLOW
CREST OF DAM AT EL 61
GATE
ABUTMENT TOP EL 72
APRON EL 57
OLD FISHWAY
TAIL WATER EL 40±
FOREBAY
APRON EL 53
WALL SLOPE TO EL 65
CONCRETE BAFFLES
WALL TOP EL 65
WALL TOP EL 55
ICE CHUTE
PROPOSED POWERHOUSE
TAIL RACE
CINDER FILL
SECTION B-
CREST
LOW WATER

PLAN



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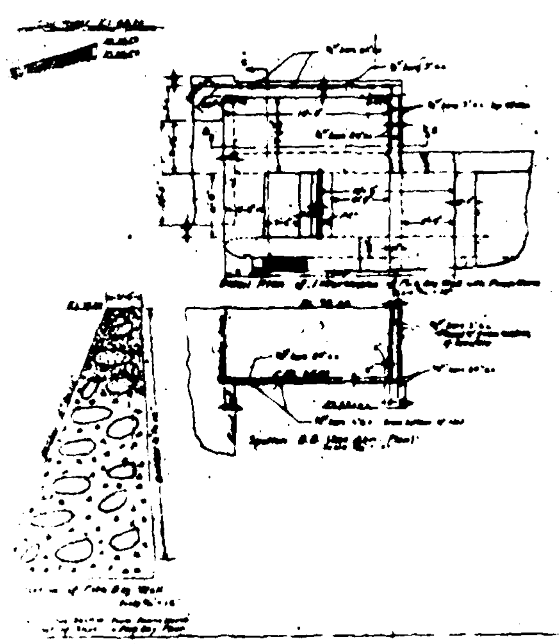
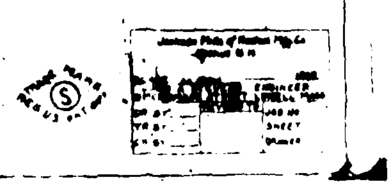
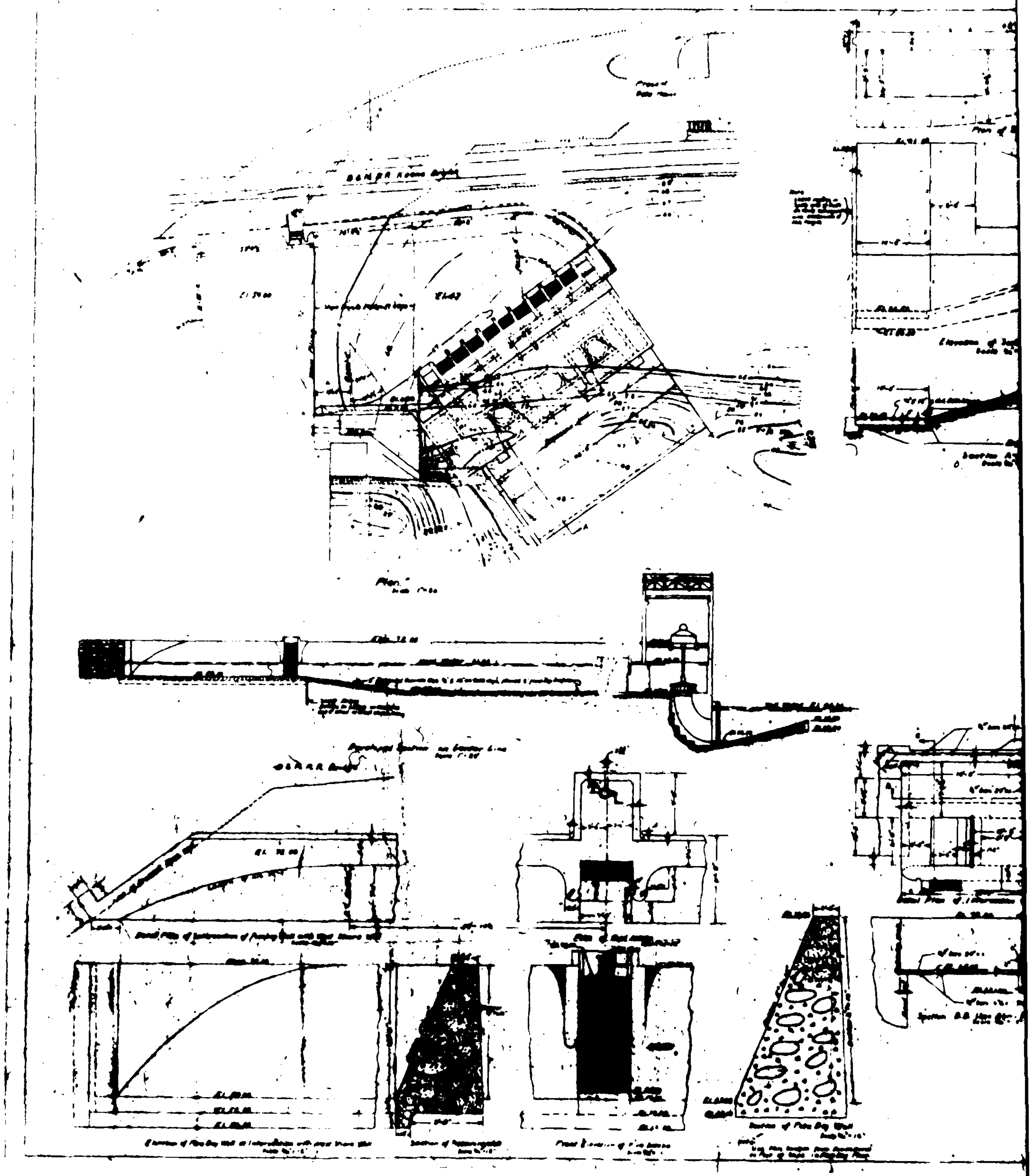
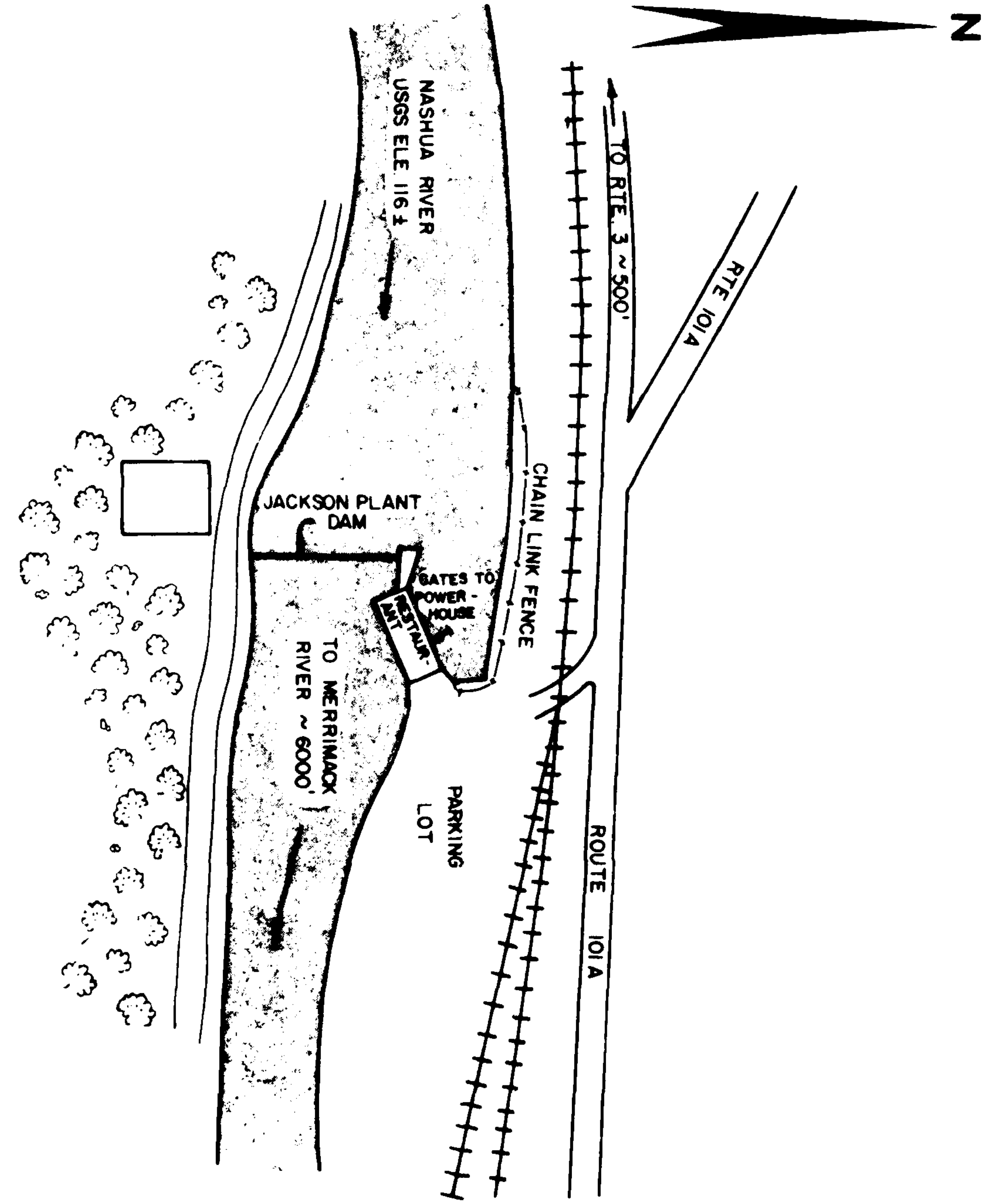








GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC. GEOTECHNICAL CONSULTANTS NEWTON UPPER FALLS, MASS.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

SITE PLAN

JACKSON PLANT DAM — NEW HAMPSHIRE

SCALE 1" ≈ 200'

DATE OCTOBER 1978

FILE No. 2201

APPENDIX B

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
Upstream hazard areas in event of backflooding	NAC	Considerable business along the river
Changes in nature of watershed		Area already well developed
OPERATION AND MAINTENANCE FEATURES		
Reservoir regulation plan		None
Maintenance	NAC	Poor

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
Cracking	AC	Random cracking on forebay wall
Rusting or staining of concrete		Forebay wall stained
Efflorescence		Sidewalls adjacent to forebay platform opening are highly exudated, the balance of these walls are completely efflourescenced. The underside of first floor slab at this location has high degree of exudation and is completely saturated.
Seepage	AC	Seepage from first floor platform down face of forebay wall
DOWNSTREAM CHANNEL		
Side slopes		
Right side	NAC	Grouted slope revetment in good condition; dry slope revetment approximately 75 ft. has settled and unravelled
Left side		Slopes steep with dumped fill. Appear stable
Channel bottom		Deep channel with island adjacent to right end of building
Trees overhanging channel		A few on island; none of significance
RESERVOIR		
Shoreline		Stable, no evidence of slides
Sedimentation	NAC	Considerable sediment in forebay in front of sluice gates varies from 3.2 to 8 ft. thick

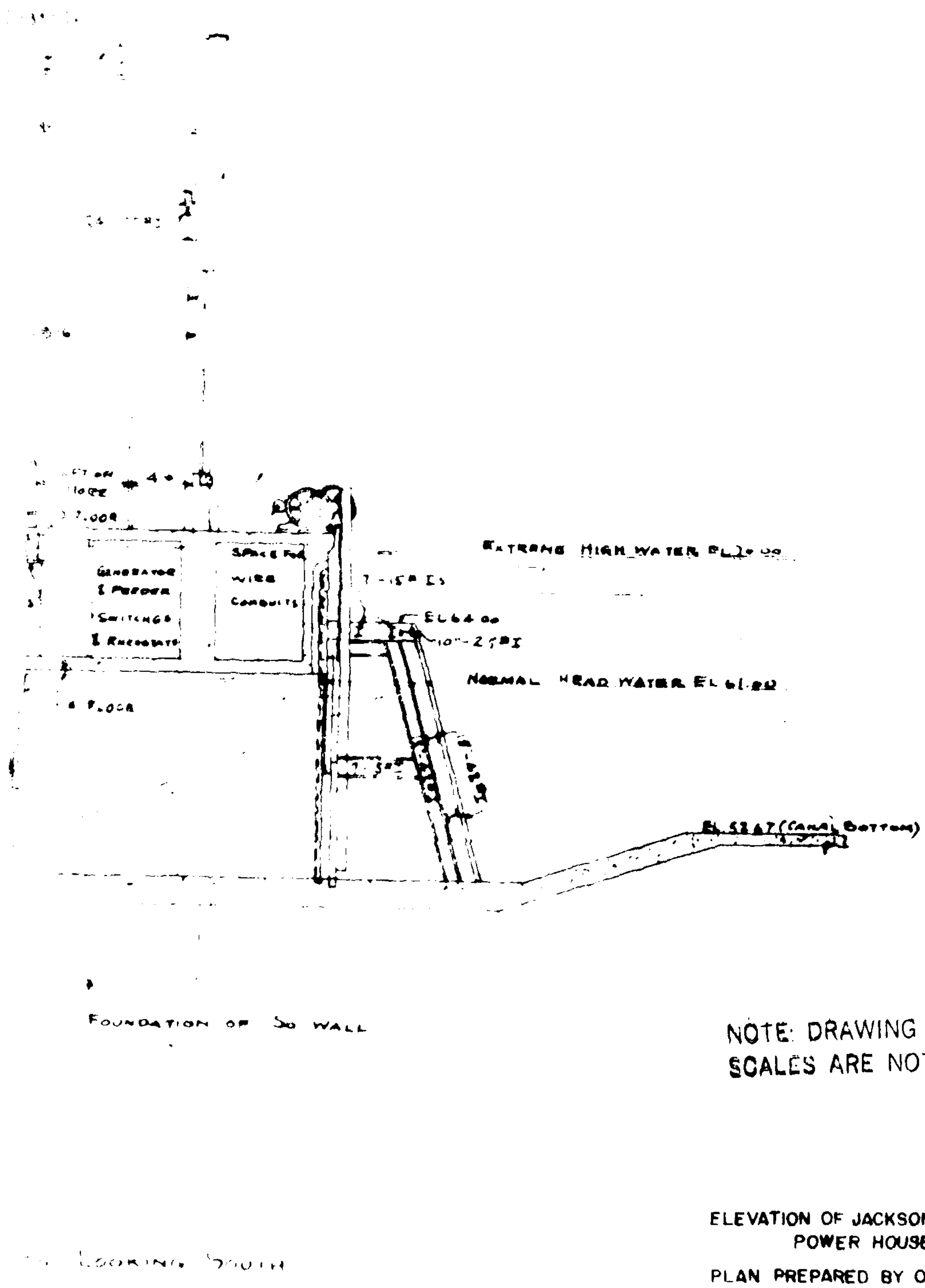
CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
F. Waste gate		
Condition	AC	Inoperable, front face silted to 6 feet below spillway crest
Condition of concrete		Very poor. Concrete eroded from 12" above water line to below surface. Reinforcing steel exposed, oxidized and expanded
G. Ice Chute		
Condition		Very poor. Timber frame rotted, chute inoperable. Concrete supporting gate guides eroded 8" deep from underside of fore-bay platform to 9' ± below platform level. Similar erosion to side walls 3' to 4' in length. Erosion up to 12" in depth at sidewalls of first platform level at skew of outlet
H. Building Structure (former powerhouse)		
Condition of concrete		Fair
Spalling	AC	Underside of first floor platform opposite ice chute spalled over 10% of its area up to 2" deep. Vertical construction joint spalled, 10' high 4" wide and 1" deep on right side of building wall.

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
Cracking	PR	Numerous horizontal and random cracks and open horizontal construction joints in abutment. Open construction joints and horizontal cracks in training wall. Horizontal cracks in secondary training wall
Rusting or staining of concrete		Stains on abutment due to minor rust from fence posts
Visible reinforcing		Located at both side walls of ice chute outlet up to 3' above water level
Efflorescence		Prevalent at all cracks and joints in abutment and both training walls. Exudation in secondary training wall.
Seepage		None noted
Fishway opening		Completely deteriorated and abandoned
Foreign matter		Active vegetative growth on forebay side of abutment. A 10" stump cut off above water line at abandoned fish way opening.
E. Sluice Gates to Former Powerhouse		
Condition of gates		Inoperable
Trash racks		Rusted
Intermediate piers	PR	Eroded at water line

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
Erosion	PR	Downstream face subjected to considerable surface erosion
Cracking		None noted
Rusting or staining of concrete		Surface heavily stained
Visible reinforcing		None noted
Seepage		None noted
C. Spillway - Stone Gravity Section With Concrete Cap		
Condition of concrete		Cap submerged, top surface is in good condition.
Stone masonry		Cannot be observed
D. Left Spillway Abutment		
Condition of concrete		Poor
Spalling		Extensive spalling over 5% of abutments vertical face. Training wall subjected to extensive spalling. The secondary training wall severely spalled over entire top surface and 75% of upstream face, up to 2" deep
Erosion	PR	Secondary training wall eroded at its downstream end approxi- tely 4 square feet. Erosion at outlet of ice chute corners 10' high and up to 6" deep

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
Dry stone masonry wall	AC	Unravelled at mid-section
Sluice Gate Structure (left upstream wall)		
Condition of gate		Inoperable
Trash rack		Rusted
Condition of concrete		Very poor - one wall bulging
Spalling		Extreme, up to 4" deep
Cracking		Up to [illegible]" wide
Efflorescence		Severe with associated exudation
Visible reinforcing	AC	Over 25% of wall faces and slab
OUTLET WORKS		
A. Approach Channel		
Slope conditions	NAC	No evidence of instability
Bottom conditions		Deep approach
Log boom		Fair condition; extends from left spillway abutment to left bank to prevent debris from floating into forebay
Debris		None noted
Trees overhanging channel	NAC	None
B. Spillway-Concrete Gravity Section		
Condition of concrete	PR	Fair

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
DAM SUPERSTRUCTURE		
Vertical alignment and movement	AC	None noted
Horizontal alignment and movement		None noted
Right abutment		
Condition of concrete		Poor
Spalling		Extensive spalling over 75% of its vertical faces up to 4" deep
Cracking		Considerable patterned horizontal cracking
Rusting or staining of concrete		Downstream face stained
Efflorescence		All horizontal cracks effloresced
Seepage		None noted
Foreign matter		Vegetation growing through joints
Left Abutment and Upstream Wall		
Condition of concrete		Very poor
Spalling		Severe spalling over 2/3 of its vertical face
Cracking		Extensive random cracking
Efflorescence		At location of all cracks
Seepage	AC	None noted



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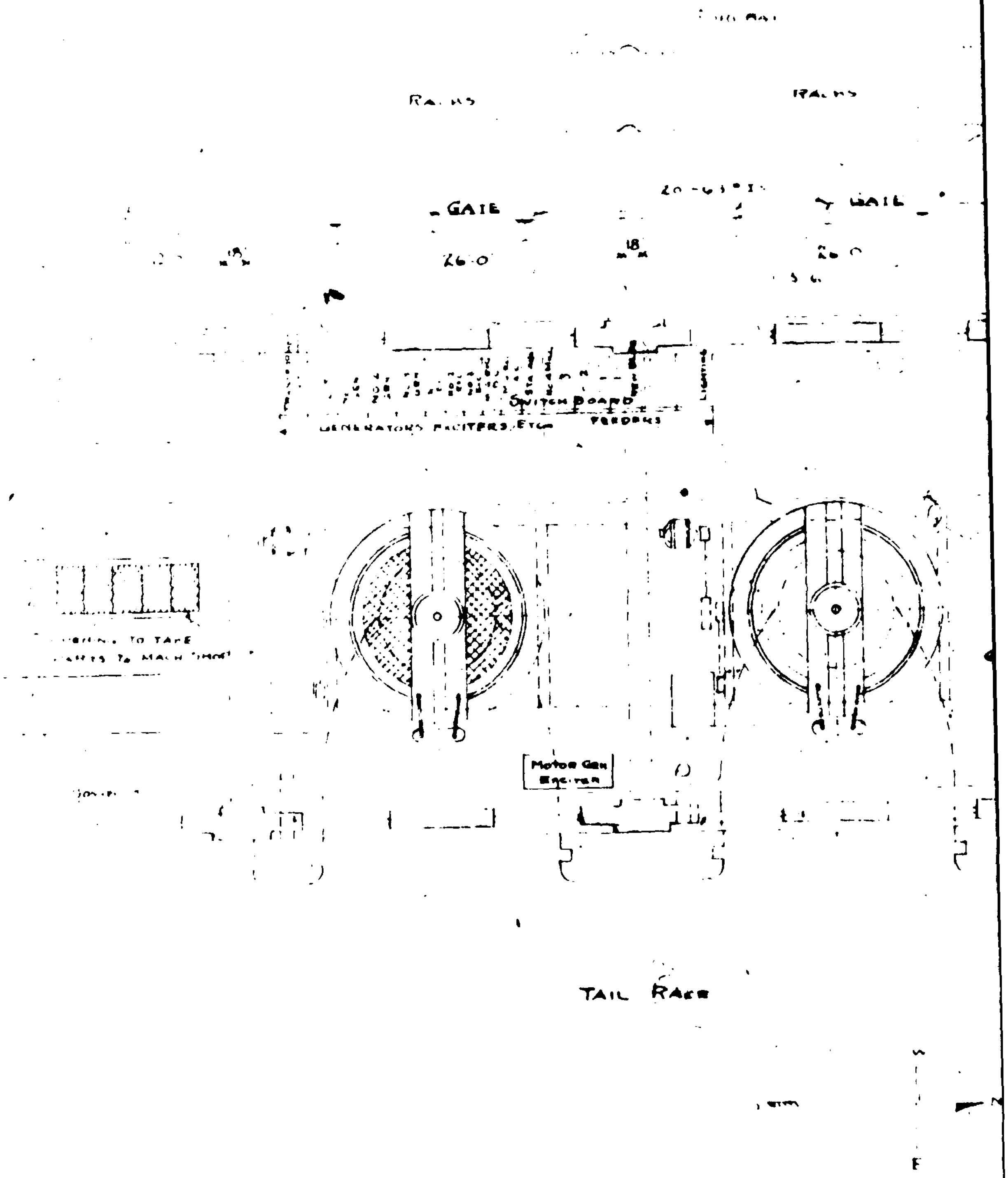
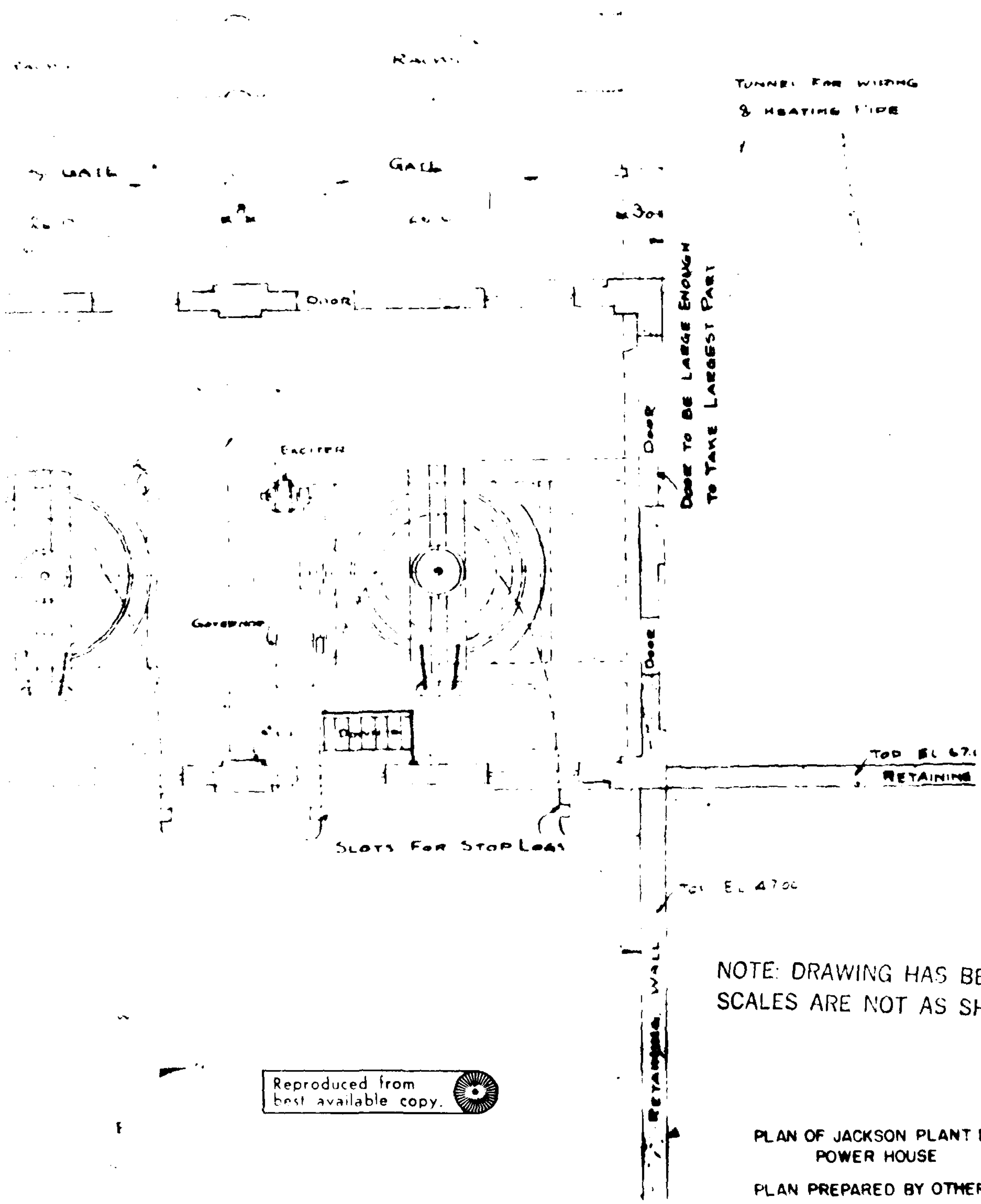
ELEVATION OF JACKSON PLANT DAM
POWER HOUSE

PLAN PREPARED BY OTHERS


RACKS
RACKS
GATE
GATE
26.0
SWITCH BOARD
GENERATORS EXCITERS, ETC.
FEEDERS
MOTOR GEN
EXCITER
TAIL RACE



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PLAN OF JACKSON PLANT DAM
POWER HOUSE

PLAN PREPARED BY OTHERS

The New Hampshire Water Resources Board (NHWRB), 37 Pleasant Street, Concord, N.H. 03301, maintains a correspondence file on the dam dating back to the 1930's. Included in the file are:

(a) Several inspection reports including those from 1930, 1940, 1951, 1966 and 1972.

(b) Site evaluation data compiled by NHWRB in 1977.

(c) Correspondence in 1975 with Sanders Associates describing basic dam data.

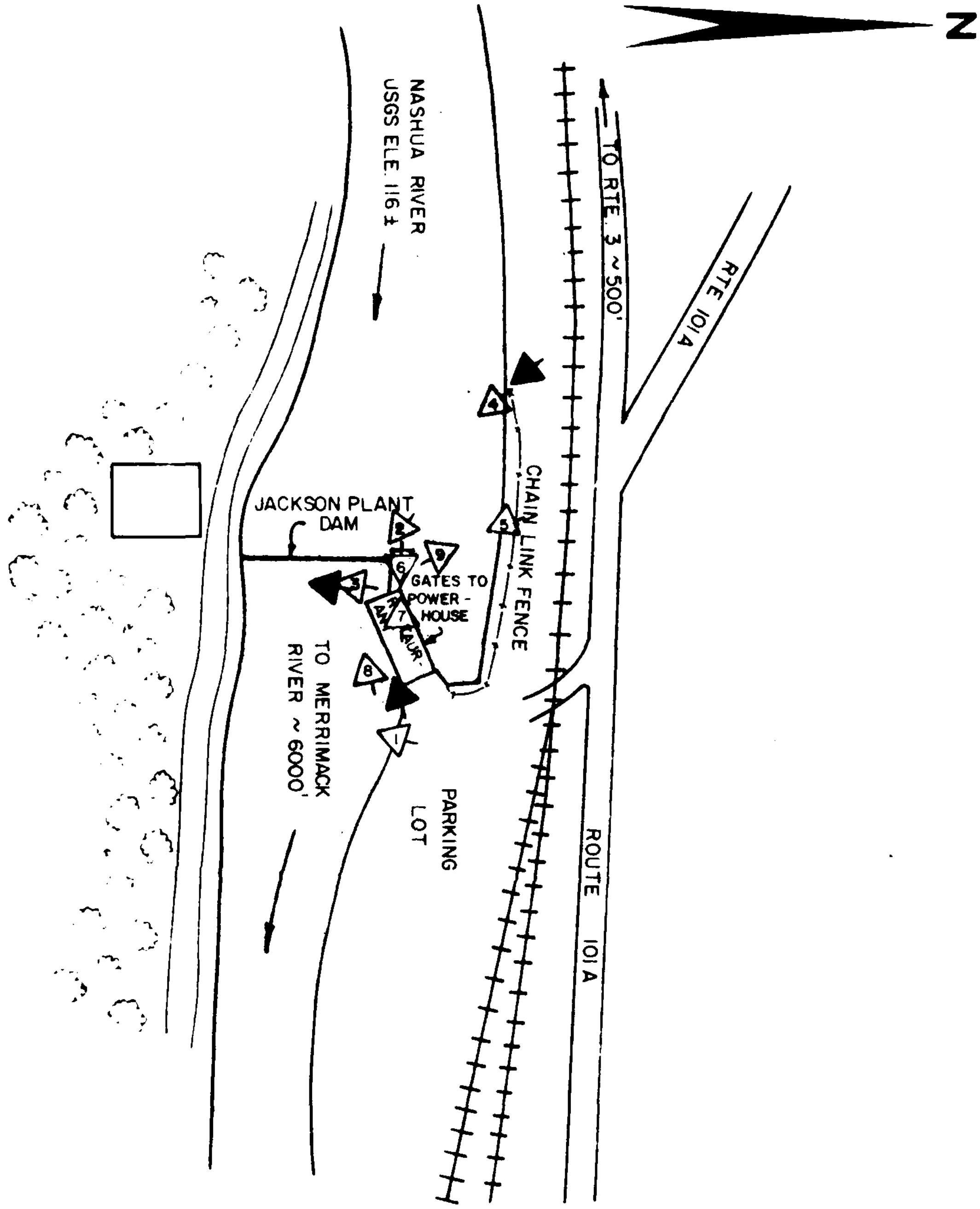
(d) The New Hampshire Water Control Commissioner's "Data on Dams in New Hampshire" dated April 10, 1939.

(e) The NHWRB's "Inventory of Dams and Water Power Developments" dated August 25, 1936.

(f) The New Hampshire Public Service Commission's "Dam Record" dated August 31, 1936.

APPENDIX C

SELECTED PHOTOGRAPHS



OVERVIEW

APPENDIX C

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC
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NEWTON UPPER FALLS, MASS

U.S. ARMY ENGINEER DIV NEW ENGLAND
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NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCATION AND ORIENTATION OF PHOTOS

FILE No 2201

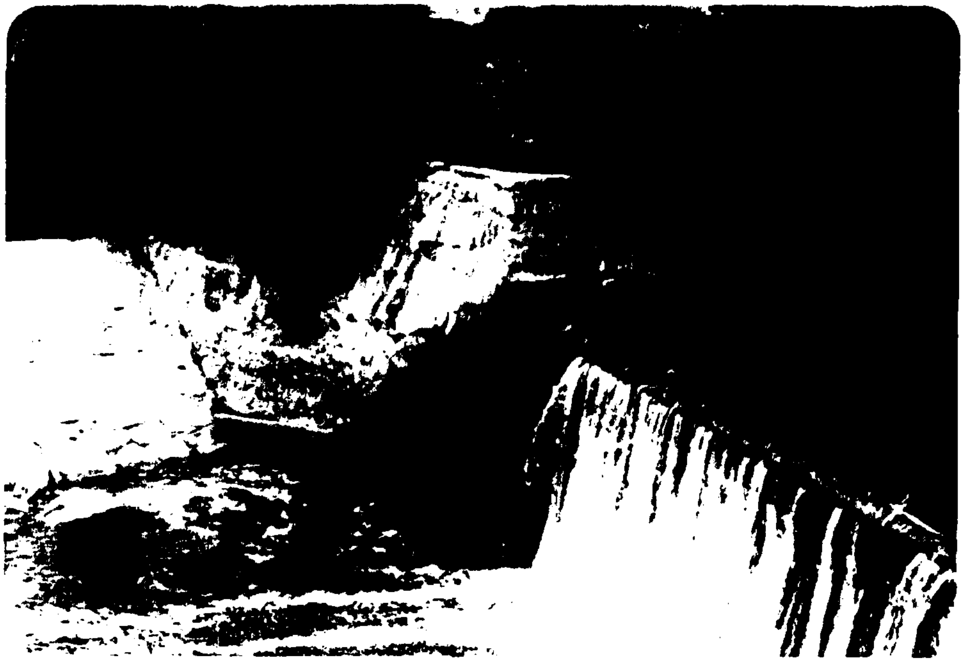
JACKSON PLANT DAM — NEW HAMPSHIRE

SCALE 1" ≈ 200'

DATE OCTOBER 1978

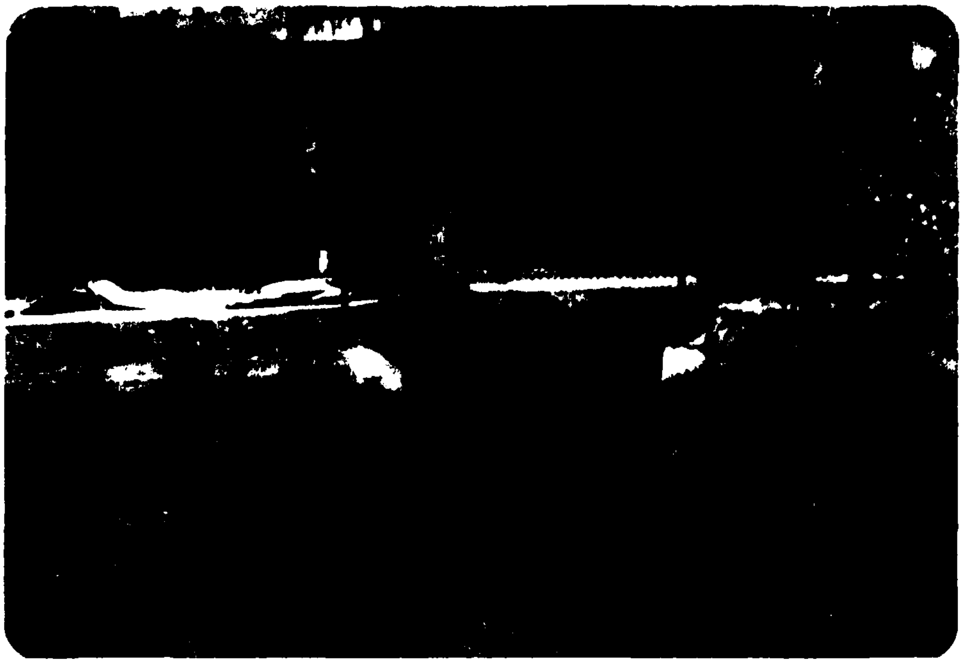
1. View from pier of collapsed slope protection on right side of downstream channel

2. View of downstream channel from pier



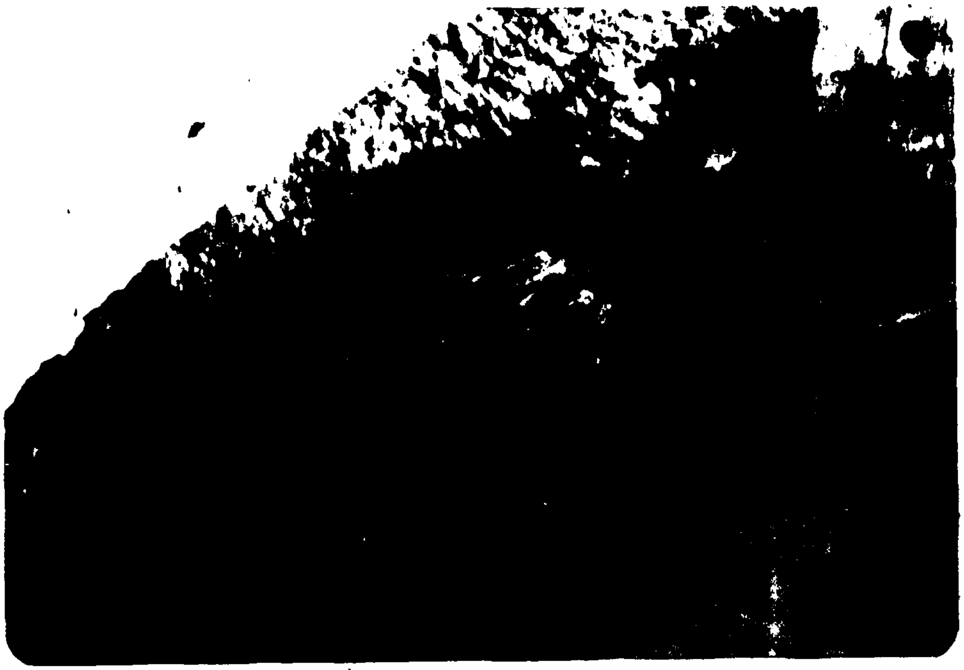
3. View from left side downstream of deteriorated concrete at right abutment

4. View from left side upstream of deteriorated concrete on upstream side of pier



5. View from left side upstream of deteriorated concrete of ice chute sluice gate structure

6. Detail of left side of ice chute gate structure showing severe erosion of concrete



7. Detail of right side of ice chute gate structure showing severe erosion of concrete including flow of water through concrete wall

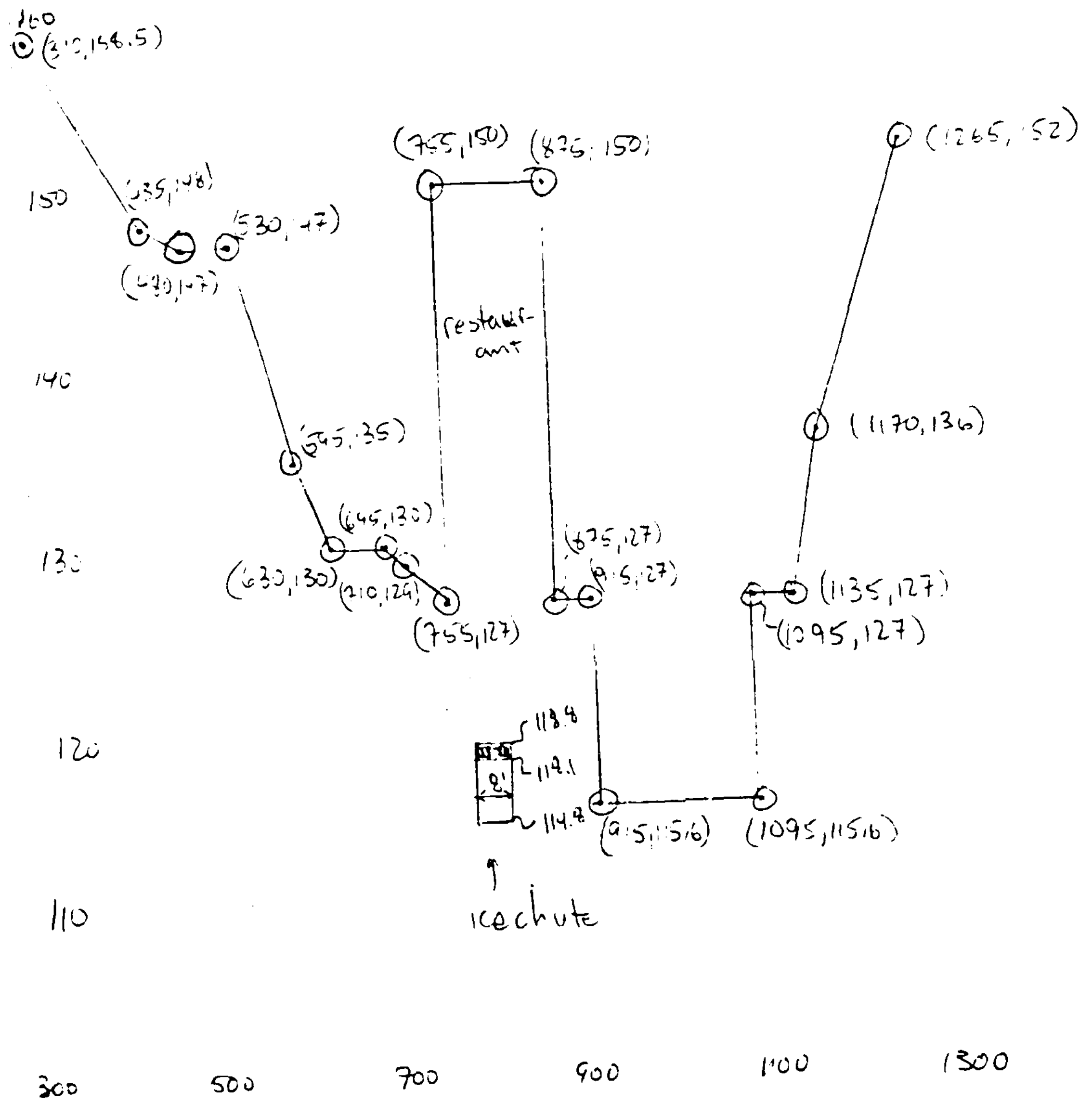
8. Detail from downstream of sluiceway outlet showing concrete deterioration and exposed rebar

9. View from pier of left upstream training wall showing deterioration of concrete and old inlet structure

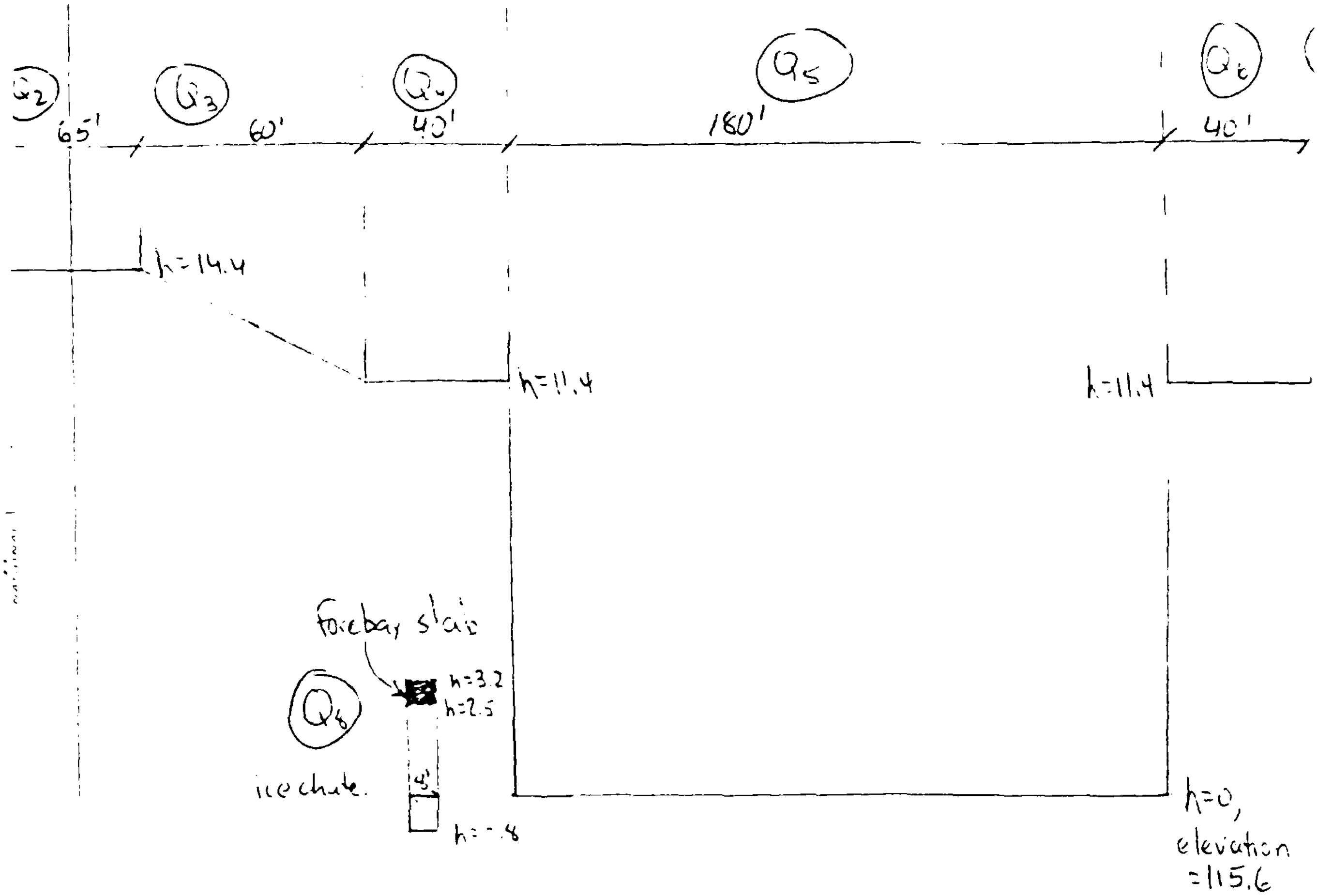
APPENDIX D

HYDROLOGIC/HYDRAULIC COMPUTATIONS

The information used to develop the cross-section at Jackson Plant Dam was obtained from field notes and from 1977 Anderson Nichols (Anco) survey data for FIS work.



The discharge over this profile is equivent to that over the simplified profile on the next page up to elevation 135, 19 feet above the spillway

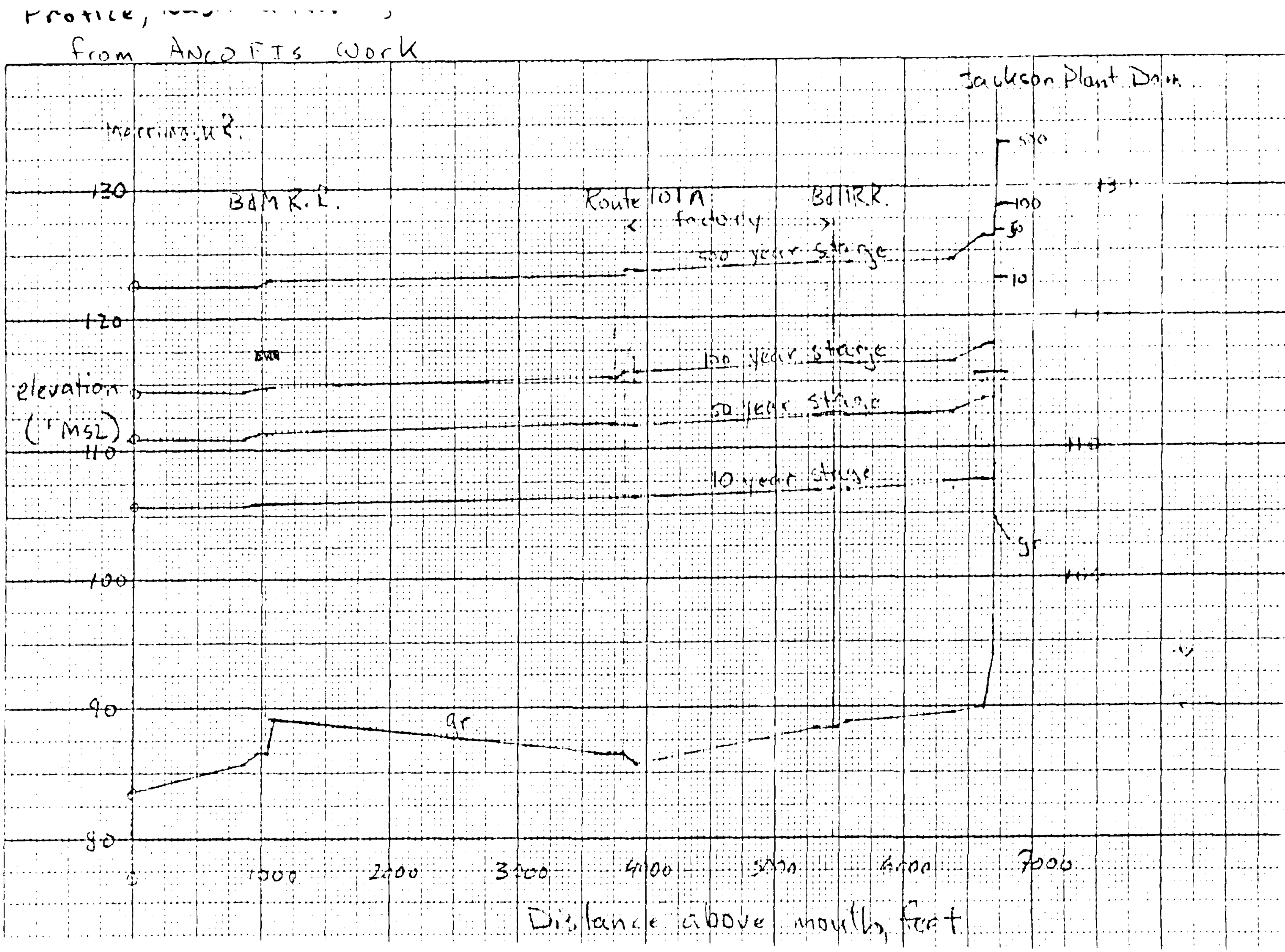


Q8: The ice chute is an 8' sharp-crested weir, with the crest .8' below the spillway crest. When the water surface reaches the bottom of the forebay slab 2.5' above the slot, the ice chute becomes a 3.3'x8' slot. When the water surface elevation reaches the top of the forebay slab, the ice chute behaves as a slot + an 8' broad-crested weir with the crest at h = 3.2.

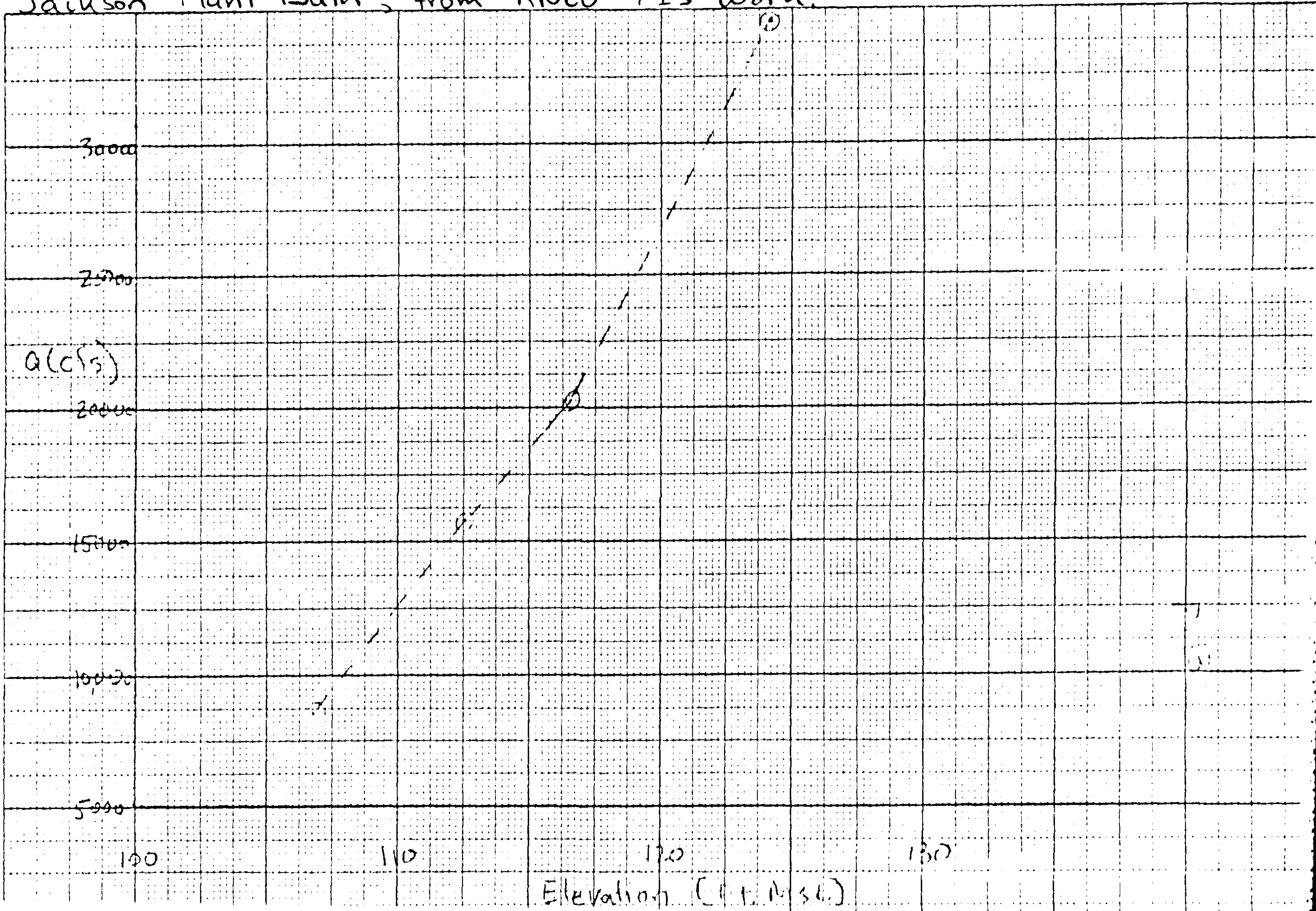
At Jackson Plant, high water on the Merrimack River can cause backwater on the Nashua River and create tailwater submergence of the spillway of Jackson Plant Dam. Our rating curve = develop

yielding an elevation of about 120.3, a rise of .8'
(Actually, the rise in water surface elevation would be less, due to the absence of increased backwater effects.) This small rise in water surface elevation is unlikely to pose a threat of loss of life. The additional flooding could cause significant problems at the Route 101A bridge, where it might cause overtopping, and at the houses near this bridge, where flooding would be increased.

If Jackson Plant Dam were to fail with the water surface at the top of abutments and with low water surface in the Merrimack, the results would differ. The only downstream structure likely to be threatened is the factory between the two bridges. The lower Merrimack level would create lower tailwater at the bridge, causing a much higher breach outflow and flood wave. Although this flood wave would attenuate rapidly due to the high storage downstream, it would probably be sufficient to cause damage to the factory which would not otherwise occur. Also, due to the rapid rate of rise to be expected there would be some danger of loss of life at this site.

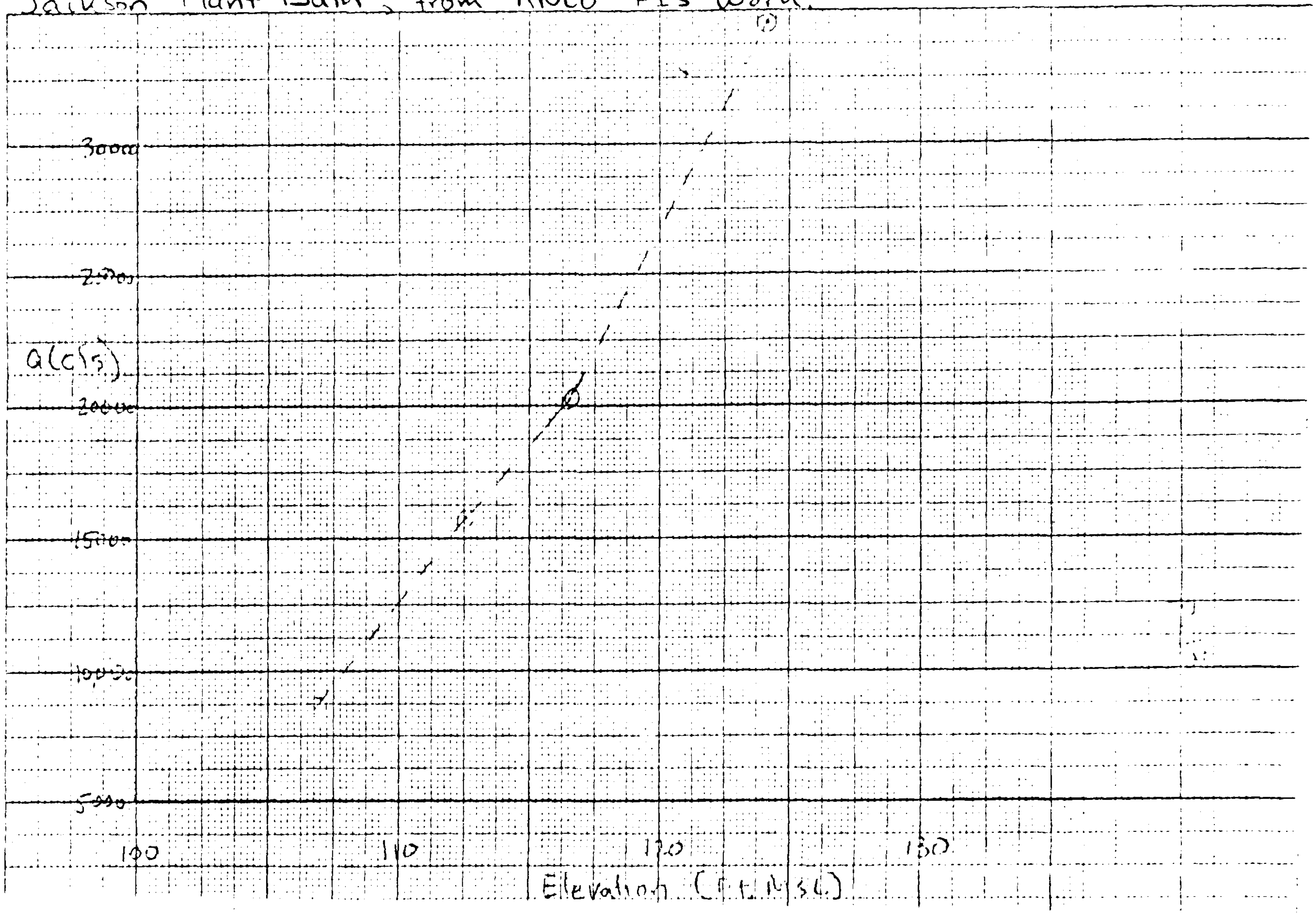

Profile,
from ANCOFTs Work
Jackson Plant Dam
BdM R.R.
Route 101A
factory
Bd RR.
500 year stage
100 year stage
50 year stage
10 year stage
500
100
50
10
gr
gr
elevation
(' MSL)
130
120
110
100
90
80
0
1000
2000
3000
4000
5000
6000
7000
Distance above mouth, feet

Jackson Plant Dam, from ANCO FIS Work.



Elevation - Discharge Curves, Downstream of Dam

Jackson Plant Dam, from ANCO FIS Work.



Peak failure outflow = 25,700 + 1730 ≅ 27,400 cfs

There are three areas of particular concern for downstream flooding. They are the railroad bridge about 1200' downstream, the Route 101 A bridge about 2500' downstream (and the houses at that bridge), and the factory on the north bank between the bridges.

An elevation discharge curve at the B&M Railroad bridge is given on p. 13. This curve relates high flow on the Nashua to high flow on the Merrimack, & is based on ANCO HEC-2 runs. At the bridge the flow just below overtopping of 25,700 cfs would give an elevation of about 124.5'. This could possibly cause damage to the structure. As can be seen on the Profile on Page 14, the same discharge with the same Merrimack River flow would create elevations about ½' lower at the factory and the Route 101 A bridge. The flow would probably cause significant damage to the factory and to the 101 A bridge, which might be overtopped. Also, there is a row of houses on the south bank at the Route 101 A bridge. These houses are slightly lower than the roadway surface elevation of 120.0', and would probably experience some flooding with a water surface of 119.0 or above.

Dam failure would increase the outflow to 27,400 cfs at the B&M bridge (assumes no attenuation),

DAM FAILURE ANALYSIS:

We will assume that the dam fails with the water surface at the abutments, 11.4 feet above the spillway crest (elevation 127.0). Normal discharge at this elevation is about 25,700 cfs. This is between the 100 year and 1/2 PMF flows.

The effect of the dam failure depends greatly on the downstream water level, which is controlled by the Merrimack River's level. In our major analysis we will assume that the Merrimack River is flooding in conjunction with the Nashua. This is reasonable since the size of the Nashua's drainage basin makes it likely that a storm producing large flows at its mouth would be regional, and also produce large flows in the Merrimack. We will also discuss the effects of dam failure with low backwater from the Merrimack.

Peak Failure Outflow = Normal Outflow + Breach outflow

Normal outflow = 25,700 cfs

Breach outflow = $Q_{p_1} = \frac{8}{27} W_b \sqrt{g} \, (y_0)^{3/2}$

Where W_b = width of breach ≅ .4(dam width) = .4(180) ≅

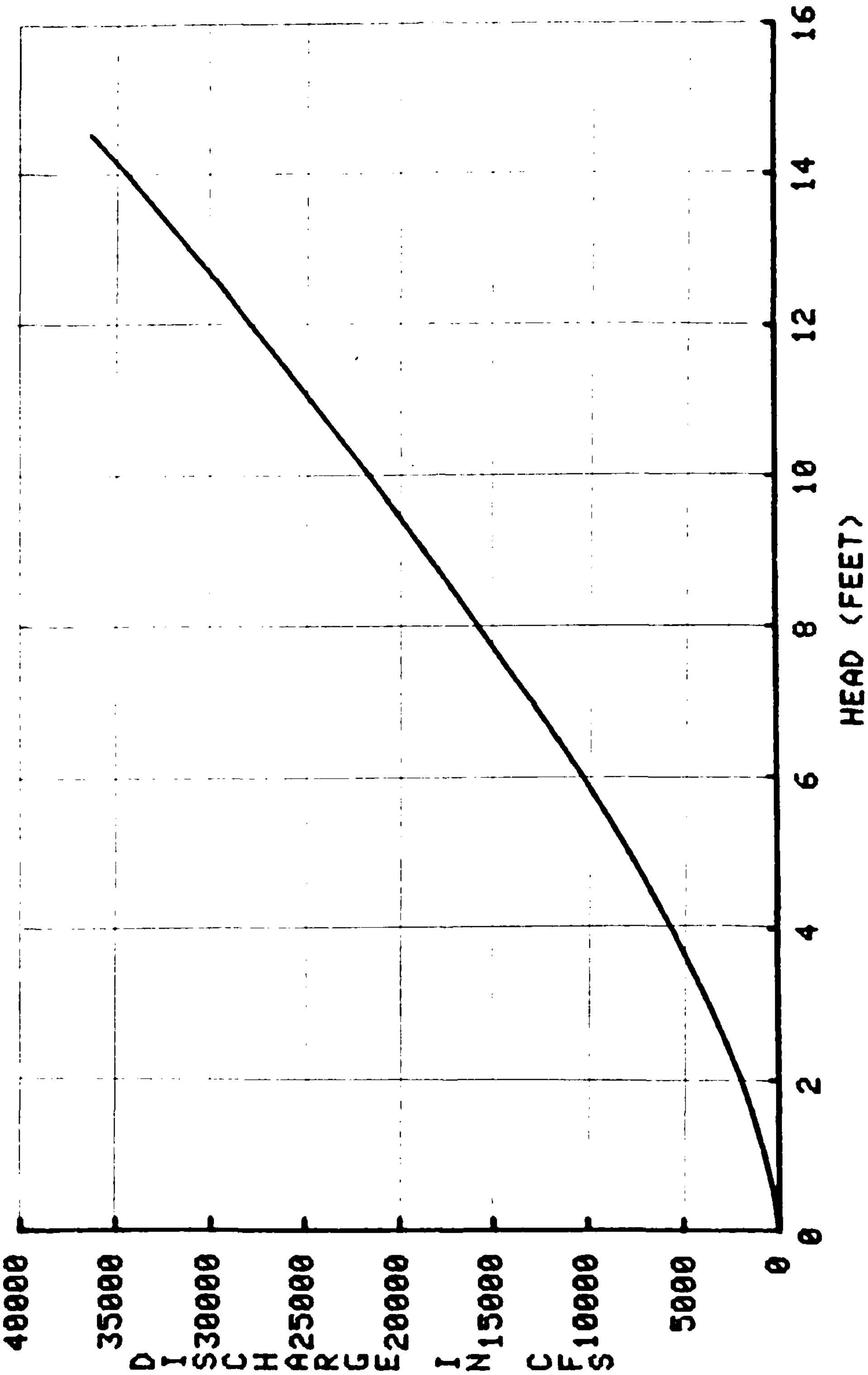
y_0 = height above backwater

backwater = $H_1 \cong 5.872 \times 10^{-4} Q_{TOT} - 9.68 \cong 5.41'$

$y_0 = 11.4 - 5.4 = 6'$

$Q_{p_1} = 8/27 \, (70) \sqrt{g} \, (6)^{3/2} = 1730$ cfs

STAGE-DISCHARGE CURVE FOR JACKSON PLANT DAM



DISCHARGE FROM JACKSON PLANT DAM AS A FUNCTION OF HEAD

HEAD (FEET)	C1	TOTAL	DISCHARGE (CFS) LEFT	RIGHT	ICE GATE	SPILLWAY
0.0	1.00	19	0	0	19	0
0.5	1.00	275	0	0	39	235
1.0	1.00	730	0	0	64	666
1.5	1.00	1316	0	0	92	1224
2.0	1.00	2007	0	0	124	1884
2.5	1.00	2791	0	0	158	2633
3.0	1.00	3656	0	0	195	3461
3.5	1.00	4581	0	0	220	4361
4.0	1.00	5580	0	0	252	5328
4.5	1.00	6646	0	0	288	6358
5.0	1.00	7773	0	0	327	7446
5.5	1.00	8959	0	0	369	8590
6.0	1.00	10200	0	0	412	9788
6.5	1.00	11494	0	0	458	11037
7.0	1.00	12839	0	0	505	12334
7.5	1.00	14233	0	0	554	13679
8.0	1.00	15675	0	0	605	15070
8.5	0.99	17019	0	0	657	16361
9.0	0.99	18477	0	0	712	17765
9.5	0.98	19959	0	0	767	19192
10.0	0.98	21462	0	0	824	20638
10.5	0.98	22978	0	0	883	22096
11.0	0.97	24503	0	0	942	23561
11.5	0.96	26035	4	4	1004	25024
12.0	0.96	27644	61	55	1066	26462
12.5	0.95	29290	164	139	1130	27857
13.0	0.94	30941	307	248	1195	29191
13.5	0.92	32571	492	378	1262	30440
14.0	0.90	34145	719	529	1329	31567
14.5	0.89	35886	1001	700	1398	32787

P.9

```
440 T2=Q6+Q7
450 T3=T2+Q5+T1+Q8
460 GOSUB 510
470 PRINT USING 480:H,C1,T3,T1,T2,Q8,Q5
480 IMAGE 2T,2D.1D,3D.2D,9D,12D,12D,13D,14D
490 NEXT H
500 END
510 C1=1
520 I1=0
530 Q5=C1*3.7*180*H↑1.5
540 C2=C1
550 T3=T2+T1+Q5+Q8
560 I1=I1+1
570 H1=5.872E-4*T3-9.68
580 IF H1<=0 THEN 650
590 H2=H-H1
600 C1=1.023-0.0305*H/H2
610 Q5=Q5*C1/C2
620 IF I1<15 THEN 530
630 IF I1<40 AND H=>14.5 THEN 530
640 T3=T2+T1+Q5+Q8
650 RETURN
```

P. 8

P. 7

```
LIST
100 REM: STAGE DISCHARGE PROGRAM FOR JACKSON PLANT DAM, JOB 165
110 REM: ON TAPE 10, FILE 56
120 C1=1
130 PAGE
140 PRINT "DISCHARGE FROM JACKSON PLANT DAM AS A FUNCTION OF HEAD"
150 PRINT USING 160:
160 IMAGE /  2T"HEAD"30T"DISCHARGE"
170 PRINT USING 180:
180 IMAGE 1T"(FEET)"32T"(CFS)"
190 PRINT USING 200:
200 IMAGE 10T"C1"5X"TOTAL"8X"LEFT"7X"RIGHT"5X"ICE GATE"5X"SPILLWAY"
210 FOR H=0 TO 14.5 STEP 0.5
220 Q1=0
230 Q2=0
240 Q3=0
250 Q4=0
260 Q6=0
270 Q7=0
280 Q5=3.7*180*H↑1.5
290 Q8=3.3*8*(H+0.8)↑1.5
300 IF H<=2.5 THEN 430
310 Q8=131.4*(H-0.8)↑0.5
320 IF H<=3.2 THEN 430
330 Q8=Q8+3*8*(H-3.2)↑1.5
340 IF H<=11.4 THEN 430
350 Q3=2.8*20*(H-11.4)*(0.5*(H-11.4))↑1.5
360 Q4=3*40*(H-11.4)↑1.5
370 Q6=2.9*40*(H-11.4)↑1.5
380 Q7=2.8*(4*(H-11.4))*(0.5*(H-11.4))↑1.5
390 IF H<=14.4 THEN 430
400 Q1=2.8*7*(H-14.4)*(0.5*(H-14.4))↑1.5
410 Q2=2.8*65*(H-14.4)↑1.5
420 Q3=2.8*60*(H-12.9)↑1.5
430 T1=Q1+Q2+Q3+Q4
```

$Q_6 = 2.9\ (40)\ (h-11.4)^{3/2}$

$Q_7 = 2.8\ (4)(h-11.4)(.5(h-11.4))^{3/2}$

Broad-crested weir over mortared concrete → C = 2.9

all others unchanged

for h = 14.4 to 19.4

$Q_1 = 2.8(7)(h-14.4)\ (.5(h-14.4))^{3/2}$

$Q_2 = 2.8(65)\ (h-14.4)^{3/2}$

$Q_3 = 2.8\ (60)\ (h-12.9)^{3/2}$

all others unchanged

The BASIC program which follows calculates the Stage-Discharge curve.

backwaters from the Merrimack River the spillway will cease to control flow significantly. This does not occur in the range of flows we consider.

There is a 30" pipe with an outlet on the left approach wall. It is assumed to be inoperable. The gates at the restaurant, except for the ice chute, are inoperable.

for h = 0 to 2.5

$$Q_5 = 3.7(180)(h)^{3/2}$$

$$Q_8 = 3.3\ (8)\ (h+.8)^{3/2}$$

$$Q_1 = Q_2 = Q_3 = Q_4 = Q_6 = Q_7 = 0$$

[for an ogee weir, C = 3.7]

[for a sharp-crested weir, C = 3.3]

for h = 2.5 to 3.2

$$Q_8 = (8)(3.3)\ \sqrt{2g}\ \sqrt{h-.8}\ C_d^{*}$$

$$= 131.4\ (h-.8)^{\frac{1}{2}}$$

all others unchanged

[for a slot, C_d depends on $\frac{b}{2h}$. For $\bar{h} \simeq 10$ (our head of interest) $\frac{3.3}{20} \simeq .2 \rightarrow C_d = .62$ from Figure 36, Rouse]

for h = 3.2 to 11.4

$$Q_8 = 131.4\ (h-.8)^{\frac{1}{2}} + 3.0(8)(h-3.2)^{3/2}$$

all others unchanged

[broad-crested weir over concrete, C = 3.0]

for h = 11.4 to 14.4

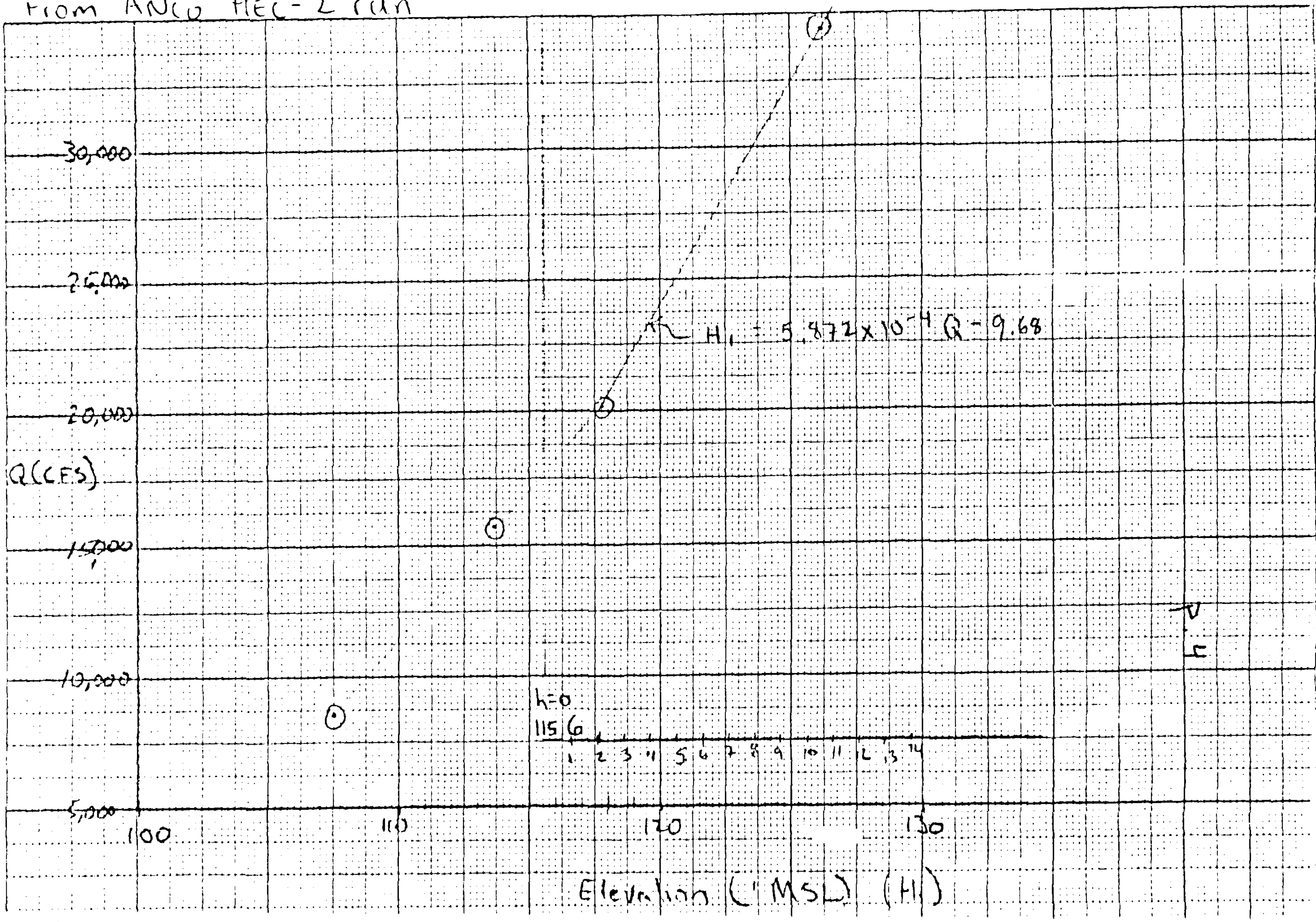
$$Q_3 = 2.8(20)\left(h-11.4\right)\left(5(h-11.4)\right)^{3/2}$$

$$Q_4 = 3.0\ (40)\ (h-11.4)^{3/2}$$

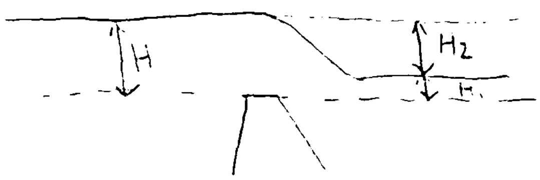
[broad-crested weir over earth → C = 2.8]

* Rouse, Engineering Hydraulics, p. 48

Downstream water surface vs. Flow - Jackson Plant Dam
From ANCo HEC-2 run



under the assumption that high flow on the Nashua River is linked with high flow on the Merrimack that's causing this problem. The tailwater submergence reduces flow over the spillway. The Bureau of Reclamation's Design of Small Dams, Figure 254 gives a plot of the reduction factor. The ratio depends on $\frac{H_2}{H}$ with H_2 and H as defined in this sketch



The relationship in Figure 254 can be approximated by

$$C_1 = \text{reduction factor} = 1.023 - \frac{.0305}{\frac{H_2}{H}} = 1.023 - .0305\frac{H}{H_2}$$

H_1 is taken from a linear estimate based on HEC-2 runs (see plot, p. 4)

$$H_1 = 5.872\times10^{-4}\,(Q_{TOT}) - 9.68$$

If H_1 is greater than 0, the downstream water surface is above the spillway and this reduction factor applies. The subroutine starting on line 520 of the BASIC program uses an iterative procedure to calculate C_1 and Q_5.

It is worthy of note that for extremely high

Test Flood Analysis

Size classification: small

Hazard classification: Significant

The hazard classification is significant because of the possibility of significant economic losses downstream in the event of dam failure. The interaction with backwater from the Merrimack River makes precise analysis of the result of a dam failure impossible but the increase in flooding failure would cause presents a threat to property & only a minimal threat to lives. Thus the significant classification seems appropriate.

Test analysis flood: 100 year to ½ PMF

ArCo's 100 year flow is 20,180 cfs. The ½ PMF is approximately equal to ½ the PMF = 34500 cfs.

Since the hazard is on the low side of significant we will use 20,180 as our test flood.

Due to the large drainage area (529 sq mi with 117 diverted leaving 412 contributing) and the small storage available, attenuation of the peak inflow by storage would be negligible (Drainage area map on p. 17, storage-elevation curve on p. 18).

The test flow of 20,180 cfs would require a head 9.7 feet over the spillway, or 1.3 feet below the [illegible]

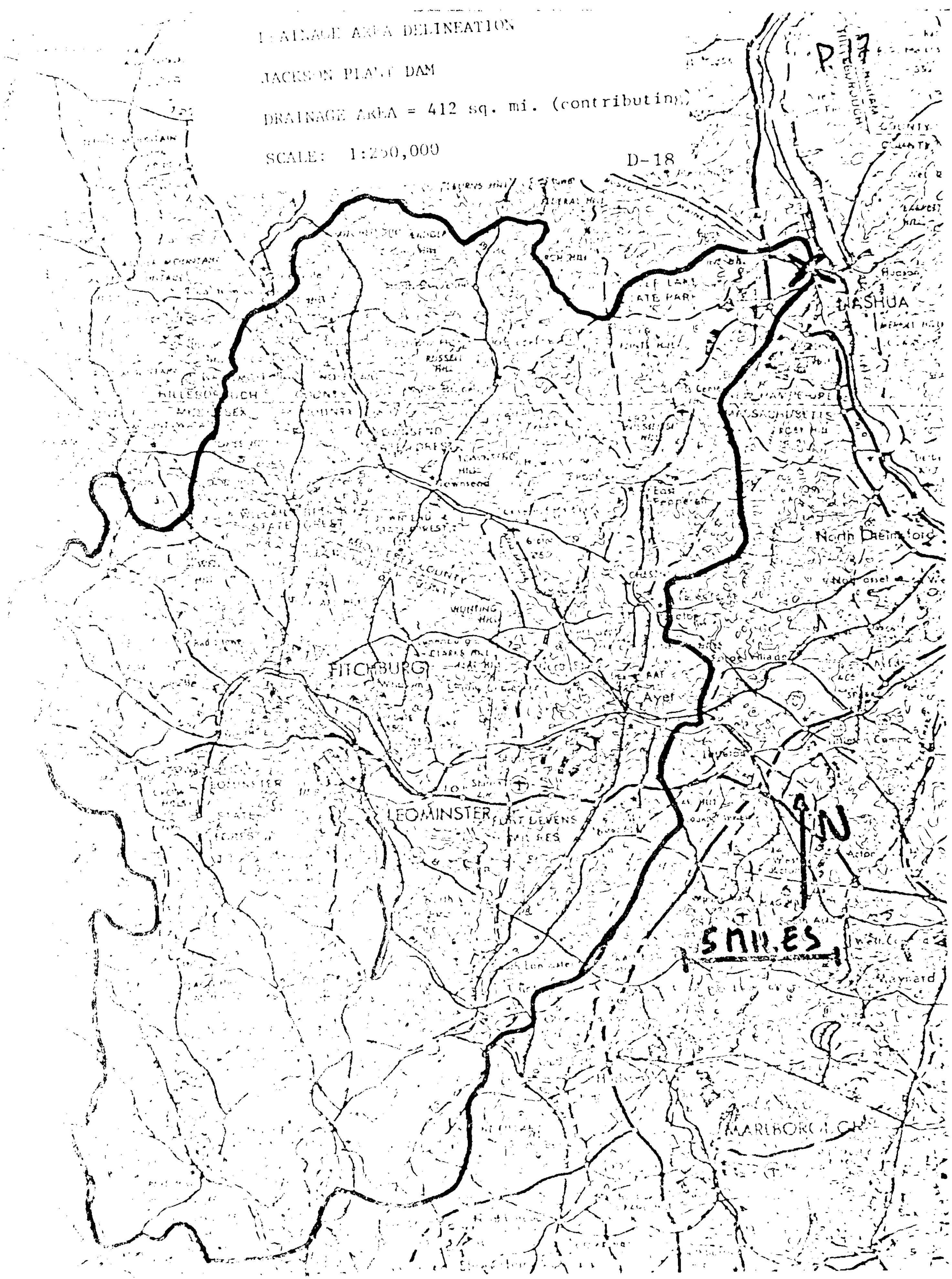
DRAINAGE AREA DELINEATION

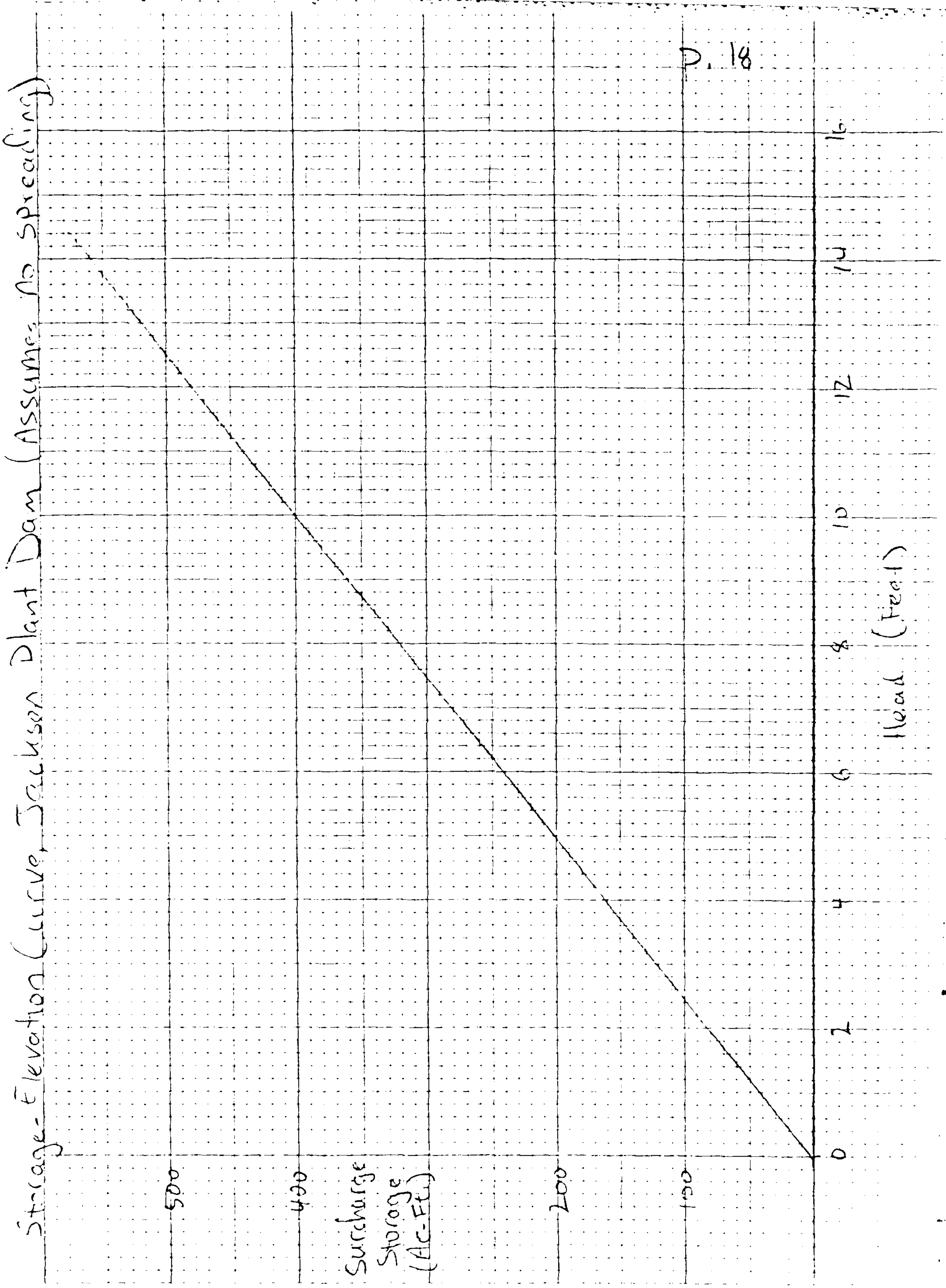
JACKSON PLANT DAM

DRAINAGE AREA = 412 sq. mi. (contributing)

SCALE: 1:250,000

D-18




D. 18
Storage-Elevation Curve, Jackson Plant Dam (Assumes No Spreading)
Head (Feet)
0
2
4
6
8
10
12
14
16
Surcharge Storage (Ac-Ft.)
100
200
400
500

APPENDIX E

INFORMATION AS CONTAINED IN

THE NATIONAL INVENTORY OF DAMS

END

FILMED

7-85

DTIC