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NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAM
EXETER WATER WORKS DAM. (U) CORPS OF ENGINEERS WALTHAM
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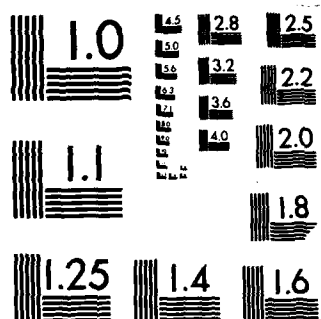
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AD-A156 436

COASTAL BASIN
EXETER, NEW HAMPSHIRE

EXETER WATER WORKS DAM

NH 00267

NHWRB NO. 82.02

PHASE I INSPECTION REPORT NATIONAL DAM INSPECTION PROGRAM



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The dam is an earthfill structure about 15 ft. high and 248 ft. long. The dam is considered to be in poor condition. There are various major concerns which must be corrected. The dam is small in size with a high hazard potential. It is recommended that the owner engage a qualified engineer to investigate the settlement of the crest of the dam and the soft, wet areas at the downstream toe of the dam and to do a detailed hydrological-hydraulic investigation.		

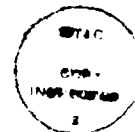
EXETER WATER WORKS DAM

NH 00267

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**COASTAL BASIN
EXETER, NEW HAMPSHIRE**



**PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM**

**NATIONAL DAM INSPECTION PROGRAM
PHASE I - INSPECTION REPORT
BRIEF ASSESSMENT**

Identification No: NH 00267
Name of Dam: Exeter Water Works Dam
Town: Exeter
County and State: Rockingham, New Hampshire
Stream: Dearborn Brook
Date of Inspection: November 20, 1979

Exeter Water Works Dam is an earthfill structure approximately 15 feet high from bottom of reservoir to crest of dam and 248 feet long from the left abutment to the spillway structure. Located at the right abutment of the dam is the principal spillway which consists of a concrete spillway with stop logs and two sluice gates that discharge into a concrete and mortared stone sluiceway. There is no emergency spillway. The overall length of the dam, including the spillway structure, is 278 feet. The upstream face of the embankment is protected by a 1.0 foot thick concrete wall, and the earthfill structure is reinforced with steel sheetpiling which extends from the crest downward approximately 18 feet.

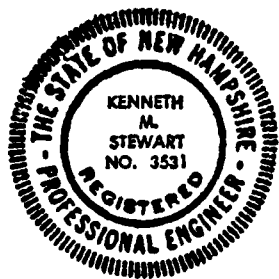
The dam impounds the Exeter Reservoir and the discharge flows to Wheelwright Brook and ultimately enters the Squamscott River approximately 0.75 miles below the dam. The dam was originally constructed to provide a primary water supply for the town of Exeter. However, its present use is as an auxiliary water supply since the Water Department currently pumps water to the water treatment facility from a nearby river. The reservoir is 0.53 miles in length with a surface area of about 18 acres. The maximum storage capacity is about 117 acre-feet.

As a result of the visual inspection and the review of available data regarding this facility, the dam is considered to be in POOR condition. Major concerns are: the presence of soft, wet ground and pools of standing water at the downstream toe of the dam and settlement of the crest of the dam in the order of 1 - 1-1/2 feet in the vicinity of the concrete intake structure which may be the result of seepage through the dam; lack of vegetation on the dirt road on the right abutment and on footpaths on the crest and downstream of the dam and partial loss of vegetation in the vehicle tracks at the toe of the dam which render these areas less resistant to erosion; the inadequacy of the spillway to pass the test flood; and animal burrows on the downstream slope of the dam.

This dam is classified as SMALL in size and a HIGH hazard structure in accordance with the recommended guidelines established by the Corps of Engineers. The test flood for this dam, therefore, ranges from one-half the Probable Maximum Flood (1/2 PMF) to the Probable Maximum Flood (PMF). Since the dam represents a high hazard structure, the full PMF was utilized for this hydrologic analysis. The test flood inflow was estimated to be 3,870 cfs, and resulted in an outflow discharge equal to 3,665 cfs which would overtop the dam crest by about 1.9 feet. The maximum spillway discharge capacity (stop logs removed and sluice gates open) with the water level at the dam crest was estimated to be 1,380 cfs or about 38 percent of the test flood discharge. A major breach with the reservoir surface at the dam crest would cause significant damage to the water treatment facility located directly below the dam, as well as the possible loss of life by more than a few individuals working therein. In addition, there would be significant damage done to Portsmouth Avenue (NH Route 108) which is a major commercial artery.

It is recommended that the owner engage a qualified registered engineer to investigate the settlement of the crest of the dam and the soft, wet areas at the downstream toe of the dam and to do a detailed hydrologic - hydraulic investigation to assess further the potential of overtopping the dam, the adequacy of the spillway to pass the test flood, and the need for and means to increase project discharge capacity. It is also recommended that the owner control trespassing on the embankment and abutments and maintain a cover of mowed grassy vegetation in those areas, remove the tree overhanging the downstream discharge channel, repair all spalled concrete, and insure the operability of all gates.

The recommendations and remedial measures are described in Section 7 and should be addressed by the owner within one year after receipt of this Phase I Inspection Report.



Kenneth M. Stewart

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N.H.P.E. 3531

S E A Consultants Inc.
Rochester, New Hampshire

PREFACE

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

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

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

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and

rarity of such a storm event, 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.

The Phase I investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespassing and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

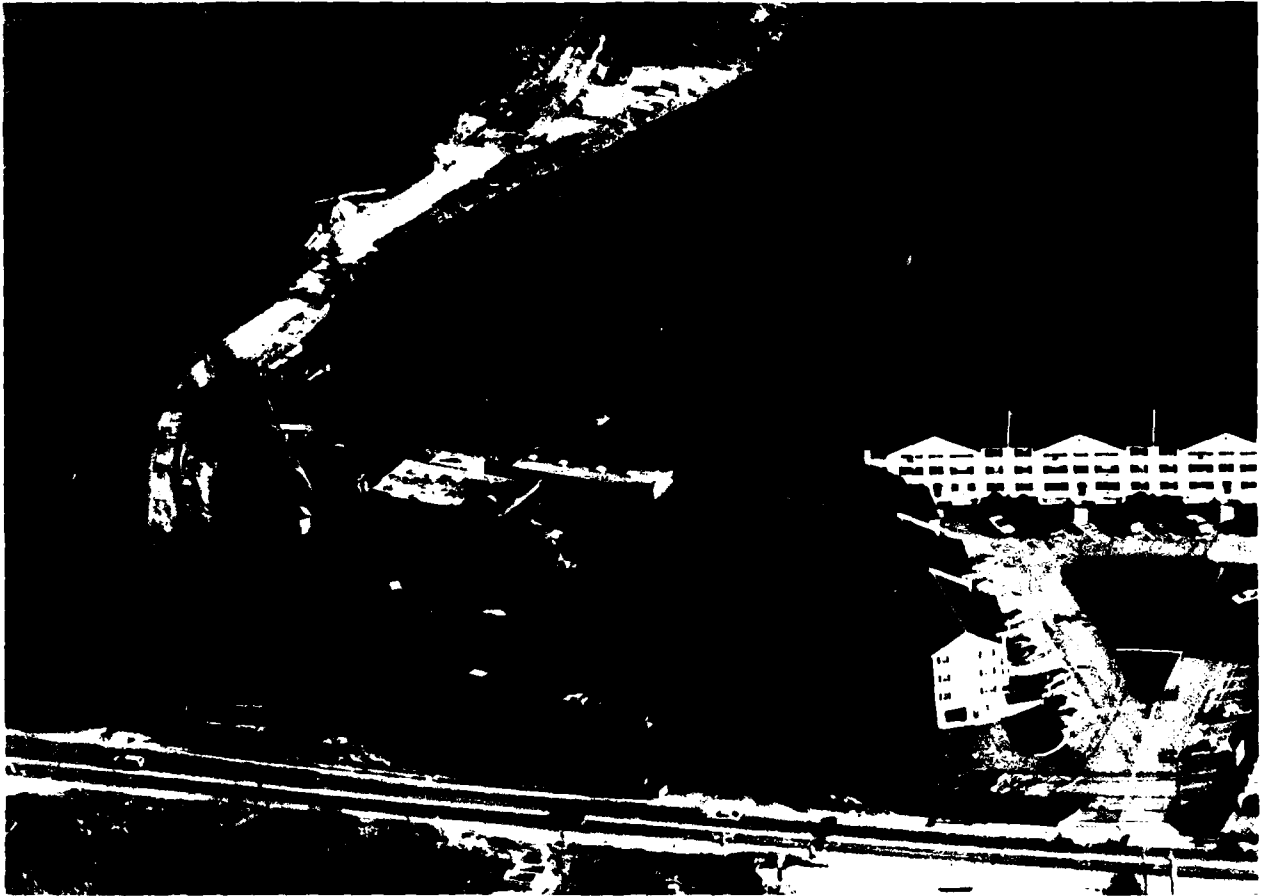
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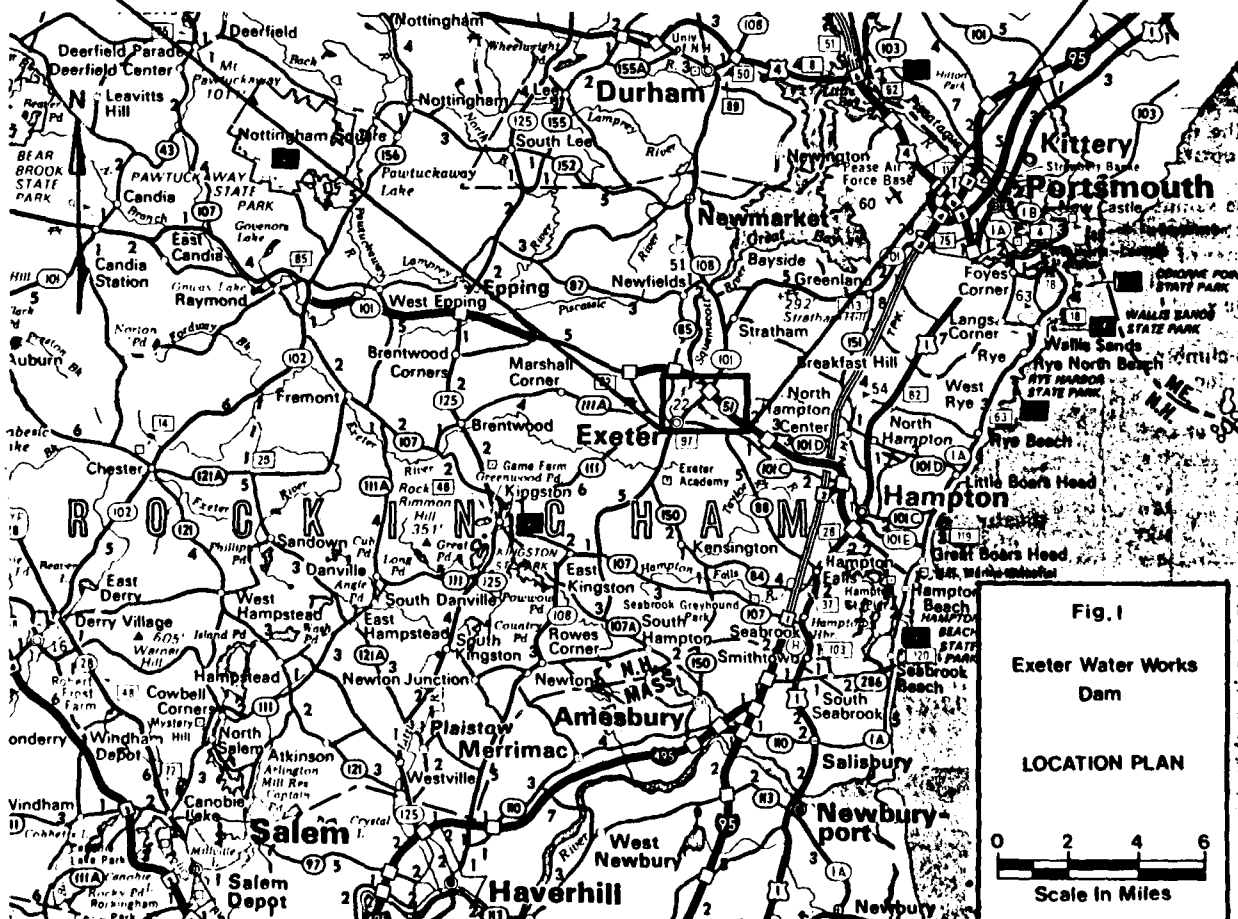
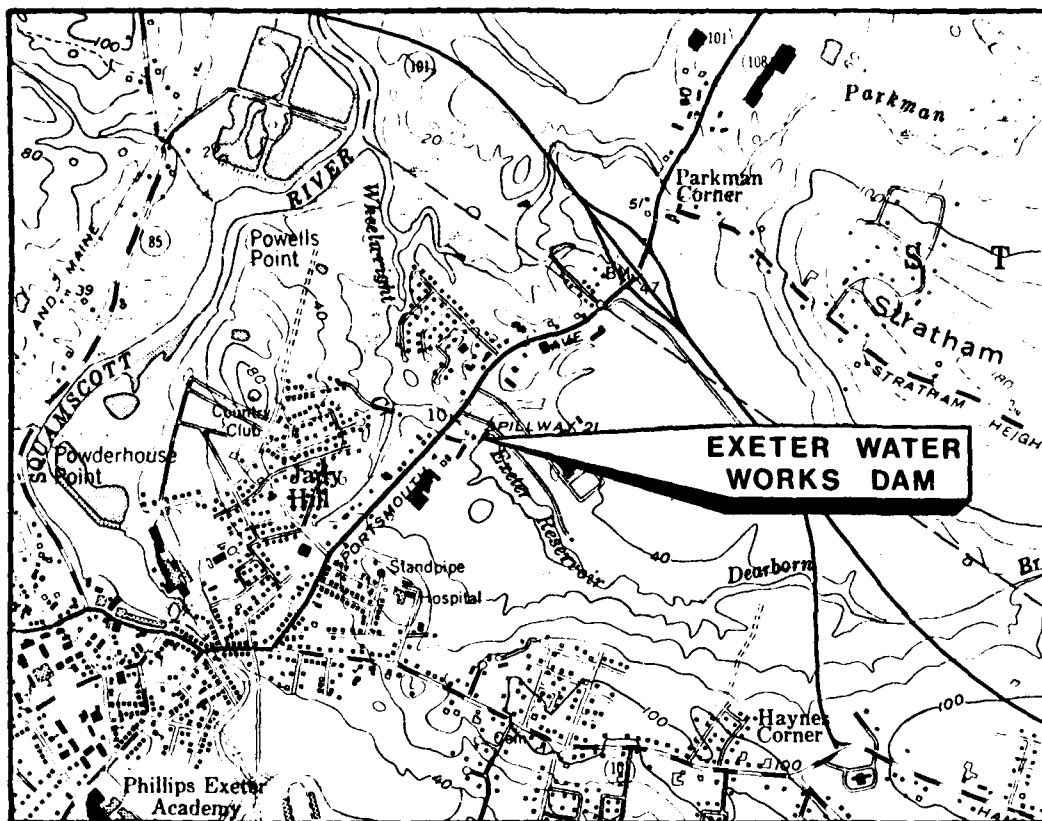
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OVERVIEW PHOTO - EXETER WATER WORKS DAM



**NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
EXETER WATER WORKS 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. S E A Consultants Inc. has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed were issued to S E A Consultants Inc. under a letter of November 5, 1979 from William Hodgson, Jr., Colonel, Corps of Engineers. Contract No. DACW33-80-C0008 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. The Exeter Water Works Dam is located in the town of Exeter, New Hampshire, at the Exeter Water Treatment Plant, off Portsmouth Avenue (New Hampshire Route 108). The dam impounds water from Dearborn Brook, which after passing over the spillway, flows in a westerly direction through a concrete sluiceway into Wheelwright Brook in Exeter, New Hampshire. The dam is shown on USGS Quadrangle, Exeter, New Hampshire, with coordinates approximately at N42°59'14", W70°56'00", Rockingham County, New Hampshire. (See Location Plan.)

b. Description of Dam and Appurtenances. Exeter Water Works Dam is an earthfill structure approximately 15 feet high from bottom of reservoir to crest of dam, and 248 feet long from left abutment to the spillway structure. The upstream face consists of a 1.0 foot thick concrete wall which extends from the crest of the dam down approximately 7 feet to the top of a 2 foot thick stone riprap slope of approximately 1 foot vertical to 3 feet horizontal (1:3) which

terminates at the bottom of the reservoir. The earthfill structure is reinforced with steel sheetpiling which extends from the crest downward approximately 18 feet. The downstream slope of earthfill structure is approximately 1 foot vertical to 2 feet horizontal (1:2) to old ground. The crest width is approximately 7 feet.

Located at the right abutment of the dam is the principal spillway which consists of a concrete spillway with stop logs and two sluice gates that discharge into an 8 foot wide concrete and mortared stone sluiceway that extends approximately 220 feet to Wheelwright Brook.

Located approximately in the center of the earthfill structure is the principal intake structure which consists of two 16 inch diameter cast iron pipes beginning approximately 27 feet out from the face of the concrete wall at the reservoir bottom. The 16 inch diameter cast iron pipes discharge into a concrete intake chamber located at the center of the earth embankment. The chamber outlets into a 24 inch diameter cast iron pipe which discharges into the Exeter Water Treatment Plant building.

c. Size Classification. Small (height - 15 feet; storage - 117 acre-feet) based on storage (less than 1,000 acre-feet and greater than or equal to 50 acre-feet) as given in the Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification. High Hazard. Failure of the dam would inundate the Exeter Water Treatment Plant which is located directly behind the dam. The water surface in the area of this facility would be more than 10 feet above the first floor. Consequently, this could result in the loss of life by more than a few individuals working at the water treatment facility. Also, the state highway located about 400 feet downstream of the dam would be impacted. Since the culverts beneath the road do not have the capacity to handle the dam failure discharge, the roadway would be overtopped by about 3 feet.

e. Ownership. The early structures of the dam are believed to have been constructed in 1886 when the initial Exeter Water Department Pump Station was built, and is owned by the Town of Exeter, Water Department, Portsmouth Avenue, Exeter, New Hampshire 03833. Telephone: (603) 778-0593.

f. Operator. The dam is maintained and operated by Nelson Belanger, Superintendent of the Exeter Water Department, Portsmouth Avenue, Exeter, New Hampshire 03833. Telephone: (603) 778-0593.

g. Purpose of Dam. The dam was originally constructed to provide a primary water supply for the town of Exeter. In 1977 the Water Department began pumping water to the water treatment facility from a nearby river, making the Exeter Reservoir an auxiliary water supply.

h. Design and Construction History. No information regarding the original design or construction of the dam was found. The early structures of the dam are believed to have been constructed in 1886 when the initial Exeter Water Department Pump Station was built. In April of 1973, the dam was intentionally breached by blasting the spillway. This apparently was done to protect the new construction of the water treatment facility and an apartment building near the dam, which

were being threatened by stormwater runoff that had filled the reservoir. Consequently, reconstruction of the dam and spillway as designed by Weston and Sampson Engineers, Boston, Massachusetts, was begun in 1973 by Harvey Construction Company of Manchester, New Hampshire. These design plans indicate the earthfill structure is constructed of a clay core built on an earth foundation. The plans and borings are available at the New Hampshire Water Resources Board. No in-depth design calculations or as-built drawings were disclosed for this dam.

i. Normal Operating Procedure. The Exeter Water Works Dam is used primarily for the retention of the Exeter Reservoir which acts as an auxiliary water supply for the town of Exeter. The normal operating procedure for this dam is to leave all the stop logs in unless the reservoir has to be lowered to facilitate repairs.

1.3 Pertinent Data

a. Drainage Area. The drainage area above the Exeter Water Works Dam covers nearly 1.8 square miles (1,150 acres), consisting of gently sloped hills surrounding relatively broad flat areas near Dearborn Brook and the reservoir. The majority of the drainage basin is heavily wooded and predominantly undeveloped. The major portion of the development lies on the southern fringe of the drainage area and consists of residential housing. An industrial firm is also located in the watershed, approximately 400 feet east (upstream) of the dam.

The topography in the drainage basin ranges from an elevation of 180 (NGVD) to an elevation of 10 feet near the base of the dam. Dearborn Brook represents the main and only well defined tributary to the reservoir. The brook originates from a swampy area on the eastern end of the watershed and flows westerly to the reservoir.

b. Discharge at Damsite.

(1) The outlet works consist of a cast in place concrete spillway with a total weir length of approximately 51 feet. The reservoir is normally maintained at an elevation of 22.95 feet NGVD, but it can be lowered by 2 feet, to elevation 20.95 feet, when the stop logs are removed. Two 2' x 2' sluice gates located at the base of the concrete spillway wall allow the reservoir to be lowered to an elevation of 15.95 feet. The water treatment facility's intake structure located in the center of the dam can draw water from the reservoir, but at present, the intake gates are closed.

(2) Maximum known flood at damsite - not known

(3) Ungated spillway capacity at top of dam

(a) Stop logs in place - 480 cfs at 24.65 elevation (375 cfs weir, 105 cfs sluice gates)

(b) Stop logs removed - 1,380 cfs at 24.65 elevation (1,275 cfs weir, 105 cfs sluice gates)

- (4) Ungated spillway capacity at test flood elevation
 - (a) Stop logs in place - 1,310 cfs at 26.55 elevation (1,190 cfs weir, 120 cfs sluice gates)
 - (b) Stop logs removed - 2,595 cfs at 26.55 elevation (2,475 cfs weir, 120 cfs sluice gates)
- (5) Gated spillway capacity at normal pool elevation - 500 cfs at 22.95 elevation upon removal of all stop logs
- (6) Gated spillway capacity at test flood elevation
 - (a) Stop logs in place - 1,190 cfs at 26.55 elevation
 - (b) stop logs removed - 2,475 cfs at 26.55 elevation
- (7) Total spillway capacity at test flood elevation
 - (a) Stop logs in place - 1,310 cfs at 26.55 elevation (1,190 cfs weir, 120 cfs sluice gates)
 - (b) Stop logs removed - 2,595 cfs at 26.55 elevation (2,475 cfs weir, 120 cfs sluice gates)
- (8) Total project discharge at top of dam
 - (a) Stop logs in place, gates closed
420 cfs at 24.65 elevation (375 cfs weir, 45 cfs bypass at right abutment)
 - (b) Stop logs removed, gates closed
1,320 cfs at 24.65 elevation (1,275 cfs weir, 45 cfs bypass at right abutment)
 - (c) Stop logs removed, gates open
1,425 cfs at 24.65 elevation (1,275 cfs weir, 105 cfs sluice gates, 45 cfs bypass at right abutment)
- (9) Total project discharge at test flood elevation - 3,665 cfs at 26.55 elevation

c. Elevation (feet, NGVD) based on datum information from plans of dam reconstruction by Weston and Sampson Engineers

- (1) Streambed at toe of dam - 10.93
- (2) Bottom of cutoff - unknown
- (3) Maximum tailwater - unknown
- (4) Normal pool - 22.95
- (5) Full flood control pool - N/A
- (6) Spillway crest (gated) - 22.95 feet (stop logs in place)
20.95 feet (stop logs removed - permanent crest)
- (7) Design surcharge (Original Design) - unknown
- (8) Top of dam - 24.65
- (9) Test flood design surcharge - 26.55

d. Reservoir (Length in feet)

- (1) Normal pool - 2,800
- (2) Flood control pool - N/A
- (3) Spillway crest pool - 2,000 (permanent crest)
2,800 (stop logs in place)
- (4) Top of dam - 3,500
- (5) Test flood pool - 4,300

e. Storage (acre-feet)

- (1) Normal pool - 79
- (2) Flood control pool - N/A
- (3) Spillway crest pool - 52 (permanent crest)
79 (stop logs in place)
- (4) Top of dam - 117
- (5) Test flood pool - 180

f. Reservoir Surface (acres)

- (1) Normal pool - 18 (stop logs in place)
- (2) Flood control pool - N/A
- (3) Spillway crest - 9.2 (permanent crest)
- (4) Test flood pool - 35.5
- (5) Top of dam - 26

g. Dam

- (1) Type - earthfill with upstream concrete wall and concrete spillway
- (2) Length - 248 feet (dam embankment)
278 feet (overall)
- (3) Height - 15 feet maximum
- (4) Top width - 7 feet
- (5) Side slopes - upstream 1V to 3H riprap to reservoir bottom,
downstream 1V to 2H earth to toe of slope
- (6) Zoning - unknown
- (7) Impervious core - clay
- (8) Cutoff - unknown
- (9) Grout curtain - none
- (10) Other - none

h. Diversion and Regulating Tunnel

Not applicable (See Section j below).

i. Spillway

- (1) Type - The spillway is a concrete U-shaped structure (see Plans and Details in Appendix B and Photo No. 14 in Appendix C) with a straight drop from the weir crest to the bottom of the sluiceway
- (2) Length of weir - 51.0 feet
- (3) Crest elevation - 22.95 (with stop logs), 20.95 (permanent crest)
- (4) Gates - two 2' x 2' sluice gates

(5) U/S Channel - Exeter Reservoir. The banks are tree lined. The slopes of the reservoir appear stable. No evidence of significant sedimentation was observed. There is one tree overhanging the approach channel to the spillway. The channel is wide and otherwise unobstructed.

(6) D/S Channel - The dam's spillway discharges into a concrete sluiceway having an average width of 8 feet and average depth of 3.5 feet. The sluiceway runs in a westerly direction for about 220 feet from the spillway to a point where it discharges into Wheelwright Brook. The brook continues in a westerly direction for about 180 feet where it passes underneath Portsmouth Avenue (NH Route 108) through one 6 foot diameter and one 4 foot diameter corrugated pipe. From here the brook follows a well defined channel about 10 feet in width with heavy overgrowth for approximately 300 feet where it discharges into an open swampy area.

j. Regulating Outlets

- (1) Invert - Spillway sluice gates - 15.95
- (2) Size - Spillway sluice gates - 2' x 2' opening
- (3) Description - Spillway sluice gates - two gates with 2' x 2' openings at bottom of spillway outlet
- (4) Control mechanism - Spillway sluice gates - manual crank-type operators on service bridge open and close gates
- (5) Other
 - (a) The water works intake from the reservoir consists of two 16-inch cast iron pipes controlled by gates in the intake structure. A 24-inch pipe carries the outflow from this structure to the water treatment facility and cannot be used to drain the reservoir. A 6-inch drain runs from the bottom of the intake structure and discharges into the sluiceway. This drain pipe could be used to dewater the reservoir, but its purpose seems to be to dewater only the intake structure.
 - (b) The 1973 dam restoration plans indicate the existence of another 16-inch cast iron pipe approximately midway between the spillway and the intake structure at invert elevation 4.4 (NGVD). Exeter Water Department personnel say the pipe is controlled by a valve located at the toe of the downstream slope of the dam and the pipe discharges into the sluiceway. A 16-inch pipe which was full of small stones was observed in the concrete sluiceway bottom just below the footbridge. Although it was not possible to verify, this pipe appears to be able to dewater the reservoir to a point significantly below the invert of the sluice gates.

SECTION 2 ENGINEERING DATA

2.1 Design

A set of plans dated 1973 showing plan, elevation, and section for repairs to the dam and construction of a new spillway are available at the State of New Hampshire Water Resources Board. The boring logs for this reconstruction were also available. No in-depth engineering calculations, as-built drawings, or specifications were found.

2.2 Construction

No construction records are available for use in evaluating the dam. Records from the State of New Hampshire Water Resources Board indicate construction and repairs to the dam began in late 1973 by Harvey Construction of Manchester, New Hampshire.

2.3 Operation

No engineering operational data was found.

2.4 Evaluation

a. Availability. Repairs to the Exeter Water Works Reservoir Dam was designed by Weston and Sampson, Engineers, Boston, Massachusetts. Other than the plans and boring logs described above, no additional engineering data was found to be available.

b. Adequacy. Available engineering data and drawings are considered adequate for a Phase I investigation.

c. Validity. The field investigation indicated that the external features of the Exeter Water Works Dam substantially agree with those shown on the furnished plans. The only apparent difference is that the visual end of sheetpiling at the left abutment is 50 feet shorter than shown on the plans.

SECTION 3 VISUAL INSPECTION

3.1 Findings

a. General. Exeter Water Works Dam impounds a reservoir of small size. The watershed above the dam consists of gently sloped hills surrounding relatively broad flat areas near Dearborn Brook and the reservoir. The majority of the drainage basin is heavily wooded and predominantly undeveloped. The downstream area is heavily developed until it passes underneath Portsmouth Avenue (NH Route 108).

The field inspection of Exeter Water Works Dam was made on November 20, 1979. The inspection team consisted of personnel from S E A Consultants Inc. and Geotechnical Engineers Inc. Inspection checklists, completed during the visual inspection, are included in Appendix A. At the time of inspection, the center section of spillway stop logs had been removed and water was passing approximately 2 inches deep over the 8 foot wide spillway thus provided. The pool elevation was at approximately 21.14 NGVD. The upstream face of the dam could only be inspected above this water level.

b. Dam. Exeter Water Works Dam is an earthen embankment about 15 feet high, 248 feet long, and 7 feet wide at the crest.

The crest of the dam is mostly covered with unmowed grass and coarse weeds (see Photo No. 11). There is a footpath partially bare of vegetation along the crest (see Photos No. 4 through 6). The upstream side of the embankment is retained by a 1.0 foot thick vertical concrete wall. There is a 1/8-inch crack in this wall approximately 18 feet from the left end of the wall (see Photo No. 10). About 2-1/2 feet downstream of this concrete wall there is a sheetpile wall which extends from the concrete spillway structure at the right end of the dam to a point near the left abutment. The crest of the dam appears to have settled about 1 - 1-1/2 feet in the vicinity of the concrete control tower which is located approximately at the center of the dam (see Photo No. 9).

The downstream slope of the dam is inclined at 1 foot vertical to 2 feet horizontal and is covered with a thick growth of grass and coarse weeds (see Photo No. 11). There are two footpaths bare of vegetation on the downstream slope near the right end of the dam. There are several animal burrows on the downstream slope (see Photo No. 13). The downstream slope of the dam is wet and soft on the downslope side of the control tower.

The ground next to the downstream toe of the dam was generally wet and soft at the time of the inspection, and there was standing water at several spots along the toe (see Photo No. 11 and Plans and Details in Appendix B). Vehicles driven along the toe of the dam have caused some rutting and loss of vegetation (see Photo No. 12).

Both the right and left abutments appear to be earth. No bedrock outcrops were observed.

Several pine trees are growing on the left abutment at about the same elevation as the top of the dam (see Photo No. 5). A pipe is discharging water on the upstream slope of the dam near the left abutment, and a bed of boulders has been placed on the slope below the end of the pipe, apparently to reduce erosion. Trespassing has destroyed some of the vegetation growing on the downstream side of the left abutment.

There is a dirt road bare of vegetation on the right abutment adjacent to the concrete spillway structure (see Photos No. 6 and 7).

c. Appurtenant Structures. An intake chamber and control tower are located at the approximate center of the dam in the downstream crest. The intake chamber controls the intake of water into the water treatment plant. The structure was repaired in 1973 and at present appears to be generally in good condition and working order.

The principal spillway is located at the right end of the dam. It is a U-shaped concrete spillway approximately 26 feet wide with a total weir length of approximately 51 feet (see Photo No. 14). It was built in 1973 to replace the old structure which had been breached. The permanent crest can accommodate removable stop logs to raise the ponding elevation approximately 2 feet. Two 2' x 2' sluice gates are located at the bottom of the spillway (see Photo No. 15). The sluice gates are operated by handwheel operators located directly above on the metal deck service bridge. The spillway, gates, service bridge and all other works related to this structure appear to be in good condition and working order except that rust buildup on the screw threads of the sluice gate operators indicates that the sluice gates have not been opened in some time.

There is a footpath, bare of vegetation, next to the right wall of the concrete and masonry sluiceway which extends a distance of about 220 feet from the concrete spillway structures to the natural earthen discharge channel downstream (see Photo No. 16). There are several small sinkholes in the earth fill behind the left wall of this same channel.

Erosion is occurring at the earthen headwall of a sedimentation basin that has been excavated on the right side of the concrete and masonry sluiceway mentioned in the preceding paragraph. This erosion is undermining a cyclone fence and trees and is progressing in the direction of the concrete spillway structure.

d. Reservoir Area. The slopes of the reservoir appear stable. No evidence of significant sedimentation was observed. There is one tree overhanging the approach channel to the spillway (see Photo No. 7). The channel is wide and otherwise unobstructed.

e. Downstream Channel. There is noticeable cracking and settlement of the concrete bottom of the sluiceway for approximately the first 100 feet down from the spillway.

There is one tree overhanging the channel between the end of the concrete and masonry channel that carries the sluiceway discharge and the highway culvert that is about 400 feet downstream of the dam (see Photo No. 17).

3.2 Evaluation

On the basis of the results of the visual inspection Exeter Water Works Dam is considered to be in poor condition.

The presence of a thick cover of grass and coarse weeds on the embankment and downstream toe makes it impossible to inspect those areas adequately, although several problems are observable as described below.

Settlement of the crest of the dam of the order of 1 - 1-1/2 feet in the vicinity of the concrete control tower and the presence of a wet, soft area on the downstream slope on the downslope side of the control tower indicate the presence of unknown conditions in the interior of the embankment which could lead to failure of the dam if not corrected.

The presence of soft, wet ground and pools of standing water at the downstream toe of the dam may be the result of seepage conditions which, if not controlled, could lead to failure of the dam. The rutting caused by vehicles at the toe of the dam and the partial loss of vegetation in the vehicle tracks will tend to exacerbate any unfavorable seepage conditions.

The lack of vegetation on the dirt road on the right abutment and on footpaths on the downstream slope, on the left abutment, and on the right side of the spillway discharge channel renders those areas less resistant to erosion by runoff from rainfall or due to overtopping if it should occur. Such erosion could result in failure of the dam.

Active erosion of the earthen headwall of the sedimentation basin on the right side of the sluiceway, which is progressing in the direction of the spillway, could lead to undermining of the spillway is not controlled.

The discharge of water from a pipe onto the upstream side of the left abutment has caused some erosion which has been temporarily alleviated by placing a pile of boulders in the discharge but which requires more permanent control measures.

Animal burrows on the downstream slope of the dam may be a focus for the development of seepage and piping.

Pine trees growing on the left abutment could cause seepage or erosion problems if a tree blows over and pulls out its roots or if a tree dies and its roots rot.

Sinkholes behind the wall on the left side of the concrete and masonry sluiceway discharge channel indicate a deterioration which, if allowed to continue, could result in erosion near the toe of the dam and exacerbation of seepage problems. Also cracking and settlement of the concrete bottom of the sluiceway indicates possible undermining of the sluiceway.

The tree overhanging the discharge channel upstream of the highway culvert could cause a blockage of the culvert pipes if it falls over and is carried downstream by water discharging from the reservoir.

SECTION 4
OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operational Procedures

a. General. The Exeter Water Works Dam is used primarily for the retention of the Exeter Reservoir which acts as an auxiliary water supply for the town of Exeter. The normal operating procedure for this dam is to leave all the stop logs in unless the reservoir has to be lowered to facilitate repairs.

b. Description of Any Warning System in Effect

No written warning system exists for the dam.

4.2 Maintenance Procedures

a. General. The owner, Exeter Water Department, is responsible for the maintenance of the dam. No formal maintenance was discussed.

b. Operating Facilities

No formal plan for maintenance of operating facilities was disclosed.

4.3 Evaluation

The current operation and maintenance procedures for Exeter Water Works Dam are inadequate to ensure that all problems encountered can be remedied within a reasonable period of time. The owner should establish a written operation and maintenance procedure as well as establishing a warning system to follow in event of flood flow conditions or imminent dam failure.

SECTION 5 EVALUATION OF HYDROLOGIC/HYDRAULIC FEATURES

5.1 General. The Exeter Water Works Dam is an earthfill dam approximately 15 feet high and 248 feet long as measured from the spillway structure along the concrete face of the dam to the south end of the dam. The dam is located on the lower reaches of Dearborn Brook and impounds a reservoir which serves as a secondary water source for the town of Exeter and not as a flood control facility. The spillway structure, which has a total weir length of approximately 51 feet, constitutes the primary outlet for the reservoir. The two 2' x 2' sluice gates located at the base of the concrete spillway provide a means for lowering the reservoir surface 5 feet below the permanent weir crest. The Exeter Water Works Dam is classified as small in size having a maximum storage of approximately 117 acre-feet at the dam crest.

5.2 Design Data. No hydrologic or hydraulic design data were disclosed.

5.3 Experience Data. No experience data prior to or after the reconstruction of the dam and spillway were disclosed. Maximum flood flows or elevations are unknown.

5.4 Test Flood Analysis. Due to the absence of detailed design and operational information, the hydrologic evaluation was performed utilizing data gathered during field inspection, watershed size and an estimated test flood equal to the Probable Maximum Flood (PMF) as determined from the "rolling drainage area curve" in the Corps of Engineers set of guide curves.

Based on a drainage area of 1.8 square miles and a Maximum Probable Flood Peak Flow Rate of 2,150 cfs/sq mile, the test flood inflow was estimated to be 3,870 cfs. The test flood was routed through the dam in accordance with the Corps of Engineers procedure for Estimating Effect of Surcharge Storage on Maximum Probable Discharge. The discharge was estimated to be 3,665 cfs. This analysis indicated that the dam crest would be overtopped by 1.9 feet. The maximum spillway capacity (stop logs removed and sluice gates open) with the water level at the dam crest was estimated to be 1,380 cfs, which is only about 38 percent of the test flood discharge.

The spillway outlet channel has sufficient capacity (approximately 1,920 cfs) to handle the maximum outflow from the spillway structure with the reservoir level at the dam crest. However, below the reconstructed spillway structure, the sluiceway is narrower, not as deep, and has a reduced slope. Consequently, the maximum capacity of the sluiceway is only about 320 cfs. For flows greater than this value, the sluiceway channel will overflow, and the water surface will spread laterally as it approaches the culverts beneath Portsmouth Avenue.

5.5 Dam Failure Analysis. The impact of dam failure with the reservoir surface at the dam crest was assessed utilizing the "Rule of Thumb" Guidance for Estimating Downstream Dam Failure Hydrographs published by the Corps of Engineers. Based on this analysis, the dam has been classified as high hazard.

Portsmouth Avenue, which crosses the stream channel approximately 400 feet below the spillway, poses a significant barrier to flow through the stream channel. The culverts beneath the roadway do not have the capacity to handle the discharge resulting from a major break at the dam or the test flood. A major break would result in appreciable damage to the water treatment facility, as well as the possible loss of life by more than a few individuals working therein, since the water treatment facility is located directly behind the dam and since the stage of the stream in this reach of the channel would be nearly 22 feet (NGVD) or more than 10 feet above the first floor elevation of the water treatment facility.

A major break would also overtop Portsmouth Avenue by approximately 3 feet and would certainly close this major commercial artery temporarily as well as probably doing permanent damage by undermining the road surface. However, Portsmouth Avenue also functions as a secondary dike and significantly reduces further downstream hazards by regulating the rate of flow. This function is demonstrated by the significantly lower stages in the stream channel reaches below Portsmouth Avenue. Reach 2 immediately below Portsmouth Avenue has a maximum stage of nearly 16 feet (NGVD) and the discharge in this reach should be confined to the stream channel. Reach 3 has a maximum stage of approximately 9 feet (NGVD) and should be well below the sills of any structures located near the stream channel.

SECTION 6 EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observations. The visual examination indicates the following potential structural problems.

- a. Settlement of the crest of the dam in the order of 1 - 1-1/2 feet in the vicinity of the concrete control tower and the presence of a wet, soft area on the downstream slope on the downslope side of the control tower indicate the presence of unknown conditions in the interior of the embankment which could lead to failure of the dam if not corrected.
- b. The presence of soft, wet ground and pools of standing water at the downstream toe of the dam may be the result of seepage conditions which, if not controlled, could lead to failure of the dam. The rutting caused by vehicles at the toe of the dam and the partial loss of vegetation in the vehicle tracks will tend to exacerbate any unfavorable seepage conditions.
- c. The lack of vegetation on the dirt road on the right abutment and on footpaths on the downstream slope, on the left abutment and on the right side of the spillway discharge channel renders those areas less resistant to erosion by runoff from rainfall or due to overtopping if it should occur. Such erosion could result in failure of the dam.
- d. Active erosion of the earthen headwall of the sedimentation basin on the right side of the spillway discharge channel, which is progressing in the direction of the spillway, could lead to undermining of the spillway if not controlled.
- e. The discharge of water from a pipe onto the upstream side of the left abutment has caused some erosion which has been temporarily alleviated by placing a pile of boulders in the discharge but which requires more permanent control measures.
- f. Animal burrows on the downstream slope of the dam may be a focus for the development of seepage and piping.
- g. Pine trees growing on the left abutment could cause seepage or erosion problems if a tree blows over and pulls out its roots or if a tree dies and its roots rot.

A thick cover of grass and coarse weeds makes it impossible to inspect the embankment and downstream toe area adequately.

6.2 Design and Construction Data. No information regarding the original design or construction of the dam was found. The early structures of the dam are believed to have been constructed in 1886 when the initial Exeter Water Department Pump Station was built.

6.3 Post-Construction Changes. In 1973 repairs were made to the existing dam. These repairs were necessary because the dam was intentionally breached in April 1973 by blasting the existing spillway. This drastic action was apparently taken to protect the new construction of the water treatment facility and an apartment building near the dam, which were being threatened by stormwater runoff that had filled the reservoir. A new concrete spillway was constructed to replace the old structure. Sheetpiling was driven beneath the base of the spillway and behind the concrete face of the dam for most of its length. The intake chamber in the center of the dam was reconstructed and a chain hoist installed.

6.4 Seismic Stability. This dam is located in Seismic Zone 2 and, in accordance with the Phase I guidelines, does not warrant seismic analysis.

SECTION 7
ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. The visual examination indicates that Exeter Water Works Dam is in poor condition. The major concerns with respect to the integrity of the dam are:

- (1) Settlement of the crest of the dam in the order of 1 -1-1/2 feet in the vicinity of the concrete control tower
- (2) Soft, wet area on the downstream slope of the dam downslope from the concrete control tower
- (3) Cracking and settlement of the concrete sluiceway bottom
- (4) Footpaths, bare of vegetation, on the downstream slope, on the left abutment, and on the right side of the spillway discharge channel
- (5) Dirt road, bare of vegetation, on the right abutment
- (6) Erosion of the earthen headwall of the sedimentation basin on the right of the sluiceway channel
- (7) Discharge of water from a pipe onto the upstream side of the left abutment
- (8) Animal burrows on the downstream slope of the dam
- (9) Trees growing on the left abutment
- (10) Sinkholes behind the wall on the left side of the concrete and masonry spillway discharge channel
- (11) Tree overhanging the downstream channel between the spillway and a highway culvert downstream of the dam
- (12) Inadequacy of the spillway to pass the test flood.

b. Adequacy of Information. (See comment under 6.2)

The information available from the visual inspection and hydraulic computations is adequate to identify the problems listed in 7.2. These problems will require the attention of a qualified registered professional engineer who will have to make additional engineering studies to design or specify remedial measures. No additional information is needed for the purposes of this Phase I investigation.

c. Urgency. The owner should implement the recommendations in 7.2 and 7.3 within one year after receipt of this Phase I report.

7.2 Recommendations

The owner should retain a registered professional engineer qualified in the design and construction of dams to:

- (1) Investigate the settlement of the crest of the dam in the vicinity of the concrete control tower and design remedial measures, if needed
- (2) Investigate the soft, wet areas on the downstream slope downslope of the concrete control tower and at the toe of the dam and design remedial measures, if needed
- (3) Investigate the cracking and settlement of the concrete sluiceway bottom and design remedial measures, if needed
- (4) Design or specify permanent procedures or construction for controlling erosion of the headwall of the sedimentation basin on the right side of the spillway discharge channel
- (5) Design or specify permanent procedures or construction for preventing erosion of the left abutment by water discharging from a pipe onto the upstream side of the abutment
- (6) Specify procedures for filling animal burrows on the downstream slope
- (7) Specify procedures for removal of trees and their root systems from the left abutment
- (8) Design remedial measures to repair the sinkholes behind the left wall of the spillway discharge channel
- (9) Do a detailed hydrologic-hydraulic investigation to assess further the potential for overtopping the dam, the adequacy of the spillway to pass the test flood, and the need for and means to increase project discharge capacity.

The owner should carry out the recommendations made by the engineer.

7.3 Remedial Measures

a. Operating and Maintenance Procedures. The owner should:

- (1) Monitor the soft, wet areas on the downstream toe and downstream slope periodically until the recommendations made in 7.2(1) and 7.2(2) have been carried out.
- (2) Keep the embankment and downstream toe area mowed.

- (3) Remove the tree overhanging the downstream discharge channel.
- (4) Control trespassing on the embankment and abutments and maintain a cover of grassy vegetation in those areas.
- (5) Repair all spalled concrete
- (6) Insure the operability of all gates
- (7) Verify the existence and operability of the reservoir drain line described in 1.3.j(5)(b).
- (8) Visually inspect the dam and appurtenant structures once a month.
- (9) Engage a registered professional engineer qualified in the design and construction of dams to make a comprehensive technical inspection of the dam once every year.
- (10) Establish a surveillance program for use during and immediately after heavy rainfall and also a warning program to follow in case of emergency conditions.

7.4 Alternatives

There are no practical alternatives to the recommendations of Section 7.2 and 7.3 except that on an interim basis, the owner may consider operating the reservoir at a lower level throughout the year so as to provide more storage for extreme flood events.

APPENDIX A
INSPECTION CHECK LIST

INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT: Exeter Water Works Dam, NH

DATE: November 20, 1979

TIME: 0800

WEATHER: Cloudy, Cool

W.S. ELEV. 21.12 U.S. 5.00 DN.S.
(U.S.G.S. Datum)

PARTY:

- | | |
|------------------------------------|-----------|
| 1. <u>Kenneth Stewart, S E A</u> | 6. _____ |
| 2. <u>Robert Durfee, S E A</u> | 7. _____ |
| 3. <u>Bruce Pierstorff, S E A</u> | 8. _____ |
| 4. <u>Philip Ricardi, S E A</u> | 9. _____ |
| 5. <u>Ronald Hirschfeld, G E I</u> | 10. _____ |

PROJECT FEATURE	INSPECTED BY	REMARKS
1. <u>Structural Stability</u>	<u>K. Stewart/R. Durfee</u>	
2. <u>Hydrology/Hydraulics</u>	<u>B. Pierstorff/P. Ricardi</u>	
3. <u>Soils and Geology</u>	<u>R. Hirschfeld</u>	
4. _____	_____	_____
5. _____	_____	_____
6. _____	_____	_____
7. _____	_____	_____
8. _____	_____	_____
9. _____	_____	_____
10. _____	_____	_____

INSPECTION CHECK LIST

PROJECT: Exeter Water Works Dam, NH

DATE: November 20, 1979

PROJECT FEATURE: Dam Embankment

NAME: _____

DISCIPLINE: _____

NAME: _____

AREA EVALUATED

CONDITIONS

DAM EMBANKMENT

Crest Elevation

24.65

Current Pool Elevation

21.12

Maximum Impoundment to Date

Unknown

Surface Cracks

None observed

Pavement Condition

Not paved

Movement or Settlement of Crest

Settlement of 1-1/2 ft next to water works inlet structure

Lateral Movement

None observed

Vertical Alignment

See "Movement or Settlement of Crest" above

Horizontal Alignment

Good

Condition at Abutment and at Concrete Structures

Unpaved and ungrassed road at right abutment next to spillway. Wet soft area on embankment next to downstream edge of control tower.

Indications of Movement of Structural Items on Slopes

None observed

Trespassing on Slopes

Two footpaths on downstream slope near spillway

Vegetation on Slopes

Heavy cover of grass and weeds on downstream slope and in vicinity of toe makes it impossible to inspect those areas adequately.

Sloughing or Erosion of Slopes or Abutments

Sloughing and erosion of earthen headwall of sedimentation basin immediately downstream of right abutment.

Rock Slope Protection - Riprap Failures

No riprap

Unusual Movement or Cracking at or near Toe

None observed

Unusual Embankment or Downstream Seepage

Toe of dam is wet and soft, with some standing water over most of its lengths

Piping or Boils

None observed

Foundation Drainage Features

None observed

Toe Drains

None observed

Instrumentation System

None observed

INSPECTION CHECK LIST

PROJECT: Exeter Water Works Dam, NH DATE: November 20, 1979
 PROJECT FEATURE: Dike Embankment NAME: _____
 DISCIPLINE: _____ NAME: _____

AREA EVALUATED	CONDITIONS
<u>DIKE EMBANKMENT</u> Crest Elevation Current Pool Elevation Maximum Impoundment to Date Surface Cracks Pavement Condition Movement or Settlement of Crest Lateral Movement Vertical Alignment Horizontal Alignment Condition at Abutment and at Concrete Structures Indications of Movement of Structural Items on Slopes Trespassing on Slopes Vegetation on Slopes Sloughing or Erosion of Slopes or Abutments Rock Slope Protection - Riprap Failures Unusual Movement or Cracking at or near Toes Unusual Embankment or Downstream Seepage Piping or Boils Foundation Drainage Features Toe Drains Instrumentation System	No dike

INSPECTION CHECK LIST

PROJECT: Exeter Water Works Dam, NH DATE: November 20, 1979
 PROJECT FEATURE: Intake Channel NAME: _____
 DISCIPLINE: _____ NAME: _____

AREA EVALUATED

CONDITIONS

OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE

a. Approach Channel

Slope Conditions	Good
Bottom Conditions	Not visible beneath reservoir surface
Rock Slides or Falls	None
Log Boom	None
Debris	None
Condition of Concrete Lining	Not applicable
Drains or Weep Holes	None

b. Intake Structure

Condition of Concrete	Not visible
Stop Logs and Slots	

INSPECTION CHECK LIST

PROJECT: Exeter Water Works Dam, NH

DATE: November 20, 1979

PROJECT FEATURE: Control Tower

NAME: _____

DISCIPLINE: _____

NAME: _____

AREA EVALUATED

CONDITIONS

OUTLET WORKS - CONTROL TOWER

a. Concrete and Structural

General Condition

Good

Condition of Joints

Good

Spalling

Moderate number of medium sized popouts

Visible Reinforcing

None

Rusting or Staining of Concrete

Slight rust staining on concrete at equipment hoist frame

Any Seepage or Efflorescence

None visible

Joint Alignment

Good

Unusual Seepage or Leaks in Gate Chamber

None visible

Cracks

None visible

Rusting or Corrosion of Steel

Slight to moderate rusting on inside chamber walls

b. Mechanical and Electrical

Air Vents

Not applicable

Float Wells

Not applicable

Crane Hoist

Chain hoist for raising and lowering screens in good shape

Elevator

Not applicable

Hydraulic System

Not applicable

Service Gates

Not visible

Emergency Gates

Not visible

Lightning Protection System

Not applicable

Emergency Power System

None

Wiring and Lighting System

Good

INSPECTION CHECK LIST

PROJECT: Exeter Water Works Dam, NH

DATE: November 20, 1979

PROJECT FEATURE: Transition and conduit

NAME: _____

DISCIPLINE: _____

NAME: _____

AREA EVALUATED

CONDITIONS

OUTLET WORKS - TRANSITION AND CONDUIT

Not visible

General Condition of Concrete

Rust or Staining on Concrete

Spalling

Erosion or Cavitation

Cracking

Alignment of Monoliths

Alignment of Joints

Numbering of Monoliths

INSPECTION CHECK LIST

PROJECT: Exeter Water Works Dam, NH

DATE: November 20, 1979

PROJECT FEATURE: Outlet Structure

NAME: _____

DISCIPLINE: _____

NAME: _____

AREA EVALUATED

CONDITIONS

OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL

Not visible - outlet channel is 24" diameter
cast iron pipe to water works.

General Condition of Concrete

Not applicable

Rust or Staining

Not applicable

Spalling

Not applicable

Erosion or Cavitation

Not visible

Visible Reinforcing

Not applicable

Any Seepage or Efflorescence

Not visible

Condition at Joints

Not visible

Drain holes

Not applicable

Channel

No channel - outlet is the inlet pipe for the
water works.

Loose Rock or Trees Overhanging
Channel

None

Condition of Discharge Channel

Not applicable

INSPECTION CHECK LIST

PROJECT: Exeter Water Works Dam, NH DATE: November 20, 1979

PROJECT FEATURE: Spillway Weir NAME: _____

DISCIPLINE: _____ NAME: _____

AREA EVALUATED

CONDITIONS

OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS

a. Approach Channel

General Conditions

Good

Loose Rock Overhanging Channel

None

Trees Overhanging Channel

One tree overhanging channel immediately upstream of spillway

Floor of Approach Channel

Not visible beneath water surface

b. Weir and Training Walls

General Condition of Concrete

Good

Rust or Staining

Slight staining at service bridge bearings

Spalling

None

Any Visible Reinforcing

None

Any Seepage or Efflorescence

None

Drain Holes

None observed

c. Discharge Channel

General Condition

Fair. Several small sinkholes behind training wall on left side of masonry sluiceway wall.

Loose Rock Overhanging Channel

None

Trees Overhanging Channel

One tree overhanging channel between downstream end of discharge sluiceway and highway culvert

Floor of Channel

Concrete-lined channel

Other Obstructions

None

INSPECTION CHECK LIST

PROJECT: Exeter Water Works Dam, NH

DATE: November 20, 1979

PROJECT FEATURE: Service Bridge

NAME: _____

DISCIPLINE: _____

NAME: _____

AREA EVALUATED

CONDITIONS

OUTLET WORKS - SERVICE BRIDGE

a. Super Structure

Bearings

Good

Anchor Bolts

Slight rusting, no washers provided

Bridge Seat

Good

Longitudinal Members

Good

Under Side of Deck

Slight Rusting

Secondary Bracing

Good

Deck

Slight Rusting

Drainage System

Not applicable

Railings

Good

Expansion Joints

None

Paint

Fair. Slight rusting throughout structure.

b. Abutment & Piers

General Condition of Concrete

Good. Slight rust stains at bearings.

Alignment of Abutment

Good

Approach to Bridge

Not applicable

Condition of Seat & Backwall

Good

APPENDIX B
ENGINEERING DATA

AVAILABLE ENGINEERING DATA

A set of plans dated 1973 showing plan, elevation and sections for repairs are available at the New Hampshire Water Resources Board, 37 Pleasant Street, Concord, New Hampshire 03301. The boring logs for these repairs are also available.

PAST INSPECTION REPORTS



State of New Hampshire

WATER RESOURCES BOARD

37 Pleasant Street
Concord, N.H. 03301

TELEPHONE 271-3405

July 12, 1978

Town of Exeter
Water Department
Exeter, New Hampshire 03833

Dear Sir:

Under the provisions of RSA Chapter 482, Sections 8 through 15, the New Hampshire Water Resources Board is authorized to inspect all dams in the state which by reason of their physical condition, height, and location may be a menace to the public safety.

The dam structure (Dam # 82.02) located on your property in Exeter, New Hampshire was inspected on April 15, 1977 and as a result of this inspection no visual discrepancies were found at the time of the inspection which would require any corrective measures.

This letter is provided for your information only. If you have any questions, please feel free to call or write.

Sincerely yours,

George M. McGee, Sr.
George M. McGee, Sr.
Chairman

GMMG/kn

NEW HAMPSHIRE WATER RESOURCES BOARD

INSPECTION REPORT

Town: Exeter Dam Number: 82.02

Name of Dam, Stream and/or Water Body: Exeter Res.

Owner: Exeter water works Telephone Number: _____

Mailing Address: _____

Max. Height of Dam: 17' Pond Area: 22 ± A Length of Dam: 300'

FOUNDATION: Earth Type unknown

OUTLET WORKS:

50' overflow spillway with 12" Flashboards
Flash boards will not fail!!
16" CI Pipe pond drain
2- 2'x2' waste gates

ABUTMENTS:

Concrete in good shape

EMBANKMENT:

Earth with concrete on upstream face
211 Vegetated downstream
20' long steel sheet piling through E of embankment

SPILLWAY: Length: 50 Freeboard: 4' (3' with flashboards)

SEEPAGE: Location, estimated quantity, etc.

None

Changes Since Construction or Last Inspection:

Tail Water Conditions:

Overall Condition of Dam: Good

Contact With Owner: Yes Mr. Belanger (Water Works Supt.)

Date of Inspection: 15 Apr 77 Suggested Reinspection Date _____

Class of Dam: Manage A

Signature S. Burnett

Date 15 Apr 77

COMMENTS:



NEW HAMPSHIRE
WATER RESOURCES BOARD

SITE EVALUATION DATA

OWNER: Exeter Water Works TELEPHONE NO. _____

MAILING ADDRESS: _____

SITE LOCATION (TOWN OR CITY) Exeter

NAME OF STREAM OR WATERBODY: Exeter Res

QUADRANGLE: Exeter 7.5 mi LOCATION

HEIGHT OF (PROPOSED, EXISTING) DAM 17 LENGTH 300

TYPE OF (PROPOSED, EXISTING) STRUCTURE Earth Embankment

DRAINAGE AREA 1,625 m POND AREA 22 A±

AVAILABLE ARTIFICIAL STORAGE: PERMANENT: _____ TEMPORARY: _____ TOTAL 200 AF

EXISTING DEVELOPMENT DOWNSTREAM OF (PROPOSED, EXISTING) STRUCTURE

Highway water treatment plant

POTENTIAL DEVELOPMENT DOWNSTREAM OF (PROPOSED, EXISTING) STRUCTURE

POTENTIAL DAMAGE DOWNSTREAM OF STRUCTURE (EXPLAIN IN DETAIL AND INCLUDE ANY POTEN-

TIAL LOSS OF LIFE: ESTIMATE) wash out of Treatment Plant

wash out of Road

OTHER COMMENTS: _____

CLASS OF STRUCTURE -- NON MENACE: MENACE A B C DAM # 82.02

DATE OF INSPECTION: 15 Apr 77

SIGNED J B Smith

SIGNATURE

DATE:

N. H. WATER RESOURCES BOARD
Concord, N. H. 03301

DAM SAFETY INSPECTION REPORT FORM

Town: Exeter Dam Number: 82.02

Inspected by: R.B. Chamberlin / DRR/psa Date: 4/25 ± 4/5 19 73

Local name of dam or water body: Exeter Reservoir

Owner: Town of Exeter Address: _____

Owner was/was not interviewed during inspection.

Drainage Area: 1.6 ± sq. mi. Stream: Dearborn Brook

Pond Area: 22 ± Acre, Storage 200 Ac-Ft. Max. Head 17 Ft.

Foundation: Type Earth, Seepage present at toe - Yes/No, _____

Spillway: Type concrete, Freeboard over perm. crest: 4',

Width 17.5', Flashboard height 1',

Max. Capacity 440 cfs c.f.s.

Embankment:- Type earth, Cover soil Width _____,

Upstream slope 3 to 1; Downstream slope 2 to 1

Abutments: Type concrete, Condition: Good, Fair, Poor

Gates or Pond Drain: Size 16' pipe Capacity _____ Type PIPE

Lifting apparatus _____ Operational condition _____

Changes since construction or last inspection: Dike failed under core wall

adjacent to pipe manhole, spillway was ^{lowered 4 feet} ~~removed~~ to save

downstream construction.

Downstream development: LARGE WATER TREATMENT PLANT BEING BUILT DOWN RIVER, AND HIGHWAY.

This dam would/would not be a menace if it failed.

Suggested reinspection date: DURING + AFTER REPAIRS

Remarks: WATER TREATMENT PLANT BEING BUILT BELOW DAM. Pond
had been empty since 1972. Pond will be used as part of plant.

M E M O R A N D U M

DATE: April 12, 1973

FROM: Robert B. Chamberlin, Civil Engineer

SUBJECT: Exeter Water Works Dam - No. 82.02

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

On April 4, 1973, I inspected the dam at the Water Works of Exeter. The reservoir had been drained last year with our permission to inspect the intake pipe and valves for possible use in the new water treatment plant they are installing this year. According to the newspaper account attached, the reservoir filled during the storm of April 2, 1973, and possible damage to the new construction and an apartment house was the reason to remove the spillway by blasting on April 3, 1973.

At the time of inspection, emergency repairs were being conducted at three different points. The remains of the concrete spillway which was blasted were being removed by an air hammer. The hole in the center of the dam where the intake pipe goes through the dam to a large manhole containing valves was being filled with sand bags. The erosion of the bank toward the apartment house on the left side of the dam was being filled rapidly with a sandy material pushed in by a bulldozer.

This dam was classified as a menace dam during 1935 and 1949 inspections.

RBC:js

NEW HAMPSHIRE WATER CONTROL COMMISSION

REPORT ON DAM INSPECTION

TOWN Exeter DAM NO. 82.02 STREAM Dearborn Brook
OWNER Water Dept, Town of Exeter ADDRESS Exeter, N.H.

In accordance with Section 20 of Chapter 133, Laws of 1937, the above dam was inspected by me on 9/26/49 accompanied by caretaker

NOTES ON PHYSICAL CONDITION

Abutments Good

Spillway Fair - cracks have been plastered up to prevent leaks at spill ponds.

Gates

Earth Embankment Good - no signs of leakage

CHANGES SINCE LAST INSPECTION Put up some masonry in spillway & spillway channel. Concrete cutoff wall looks sound.

FUTURE INSPECTIONS Yes

This dam (is) (~~is~~) a menace because State H/W immediately downstream.

REMARKS Satisfactory

Water Supply

Copy to Owner	Date

R. C. Moore
INSPECTOR

**NEW HAMPSHIRE WATER CONTROL COMMISSION
DATA ON DAMS IN NEW HAMPSHIRE**

LOCATIONSTATE NO. 82.03

Town Exeter : County Rockingham
 Stream Exeter Reservoir
 Basin-Primary Ocean : Secondary Exeter River
 Local Name
 Coordinates—Lat. 43° 00' -4,800 : Long. 70° 55' +4,800

GENERAL DATA

Drainage area: Controlled Sq. Mi.: Uncontrolled Sq. Mi.: Total 1.6± Sq. Mi.
 Overall length of dam 300 ft.: Date of Construction
 Height: Stream bed to highest elev. 17' ft.: Max. Structure 13' 5" ft.
 Cost—Dam : Reservoir

DESCRIPTION E- Concrete Stone- Gravity Type**Waste Gates**

Type
 Number : Size ft. high x ft. wide
 Elevation Invert : Total Area sq. ft.
 Hoist

Waste Gates Conduit

Number : Materials
 Size ft.: Length ft.: Area sq. ft.

Embankment

Type
 Height—Max. ft.: Min. ft.
 Top—Width : Elev. ft.
 Slopes—Upstream on : Downstream on
 Length—Right of Spillway : Left of Spillway

Spillway

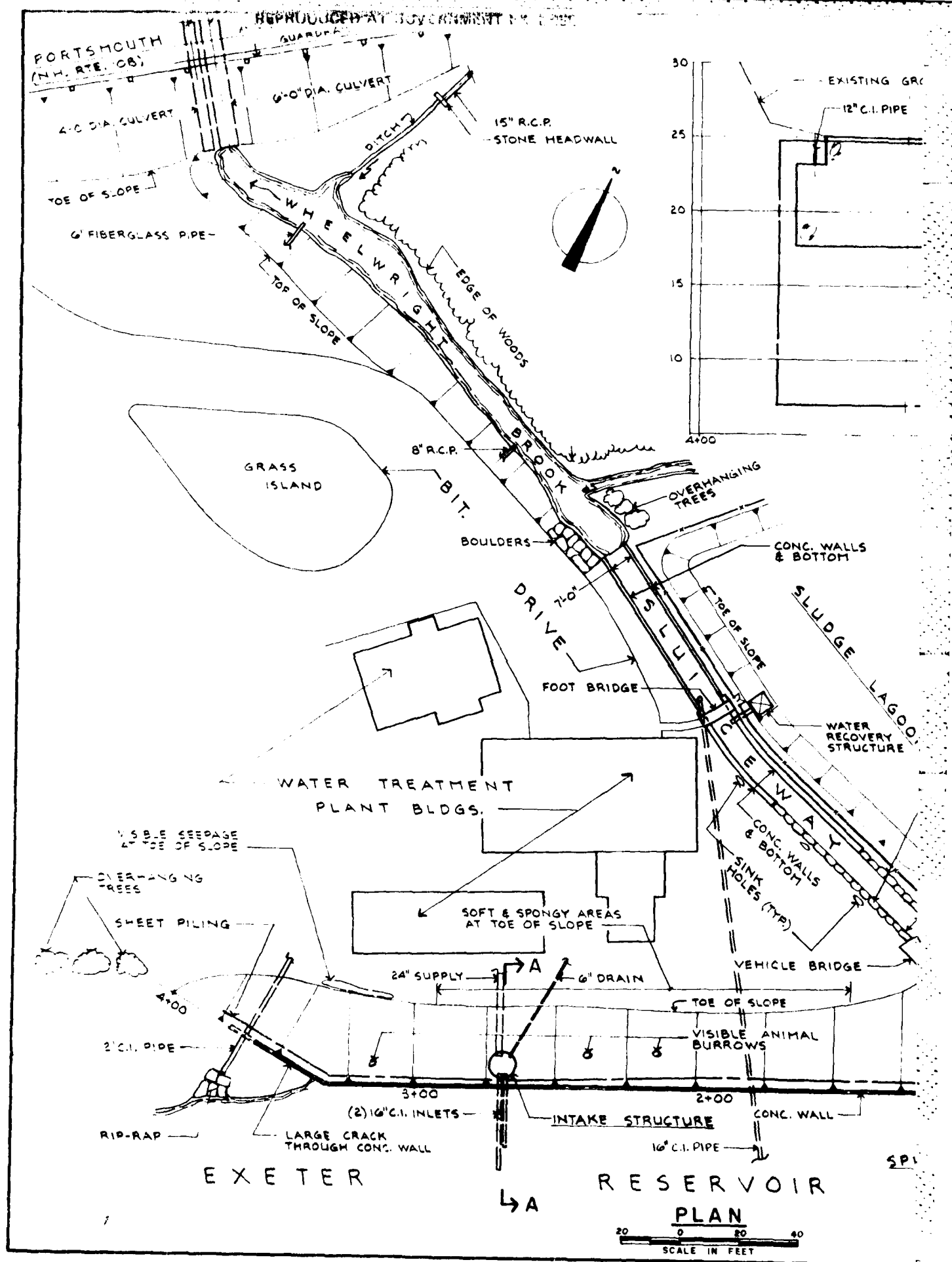
Materials of Construction
 Length—Total ft.: Net 17' -5" ft.
 Height of permanent section—max. 13' 5" ft.: Min. ft.
 Flashboards—Type : Height 10" ft.
 Elevation—Permanent Crest : Top of Flashboard
 Flood Capacity 430 cfs.: cfs/sq. mi.

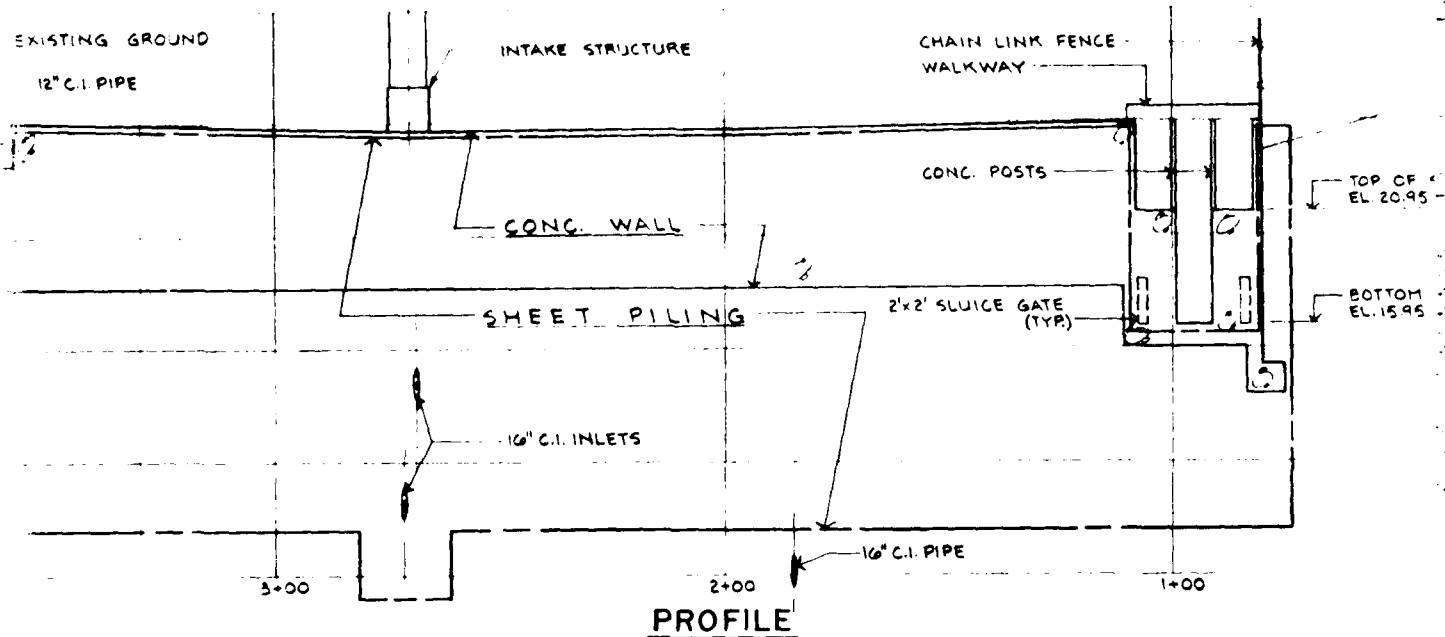
Abutments

Materials:
 Freeboard: Max. 4' 0" ft.: Min. ft.

Headworks to Power Devel.—(See "Data on Power Development")OWNER Exeter Water WorksREMARKS Use- Conservation

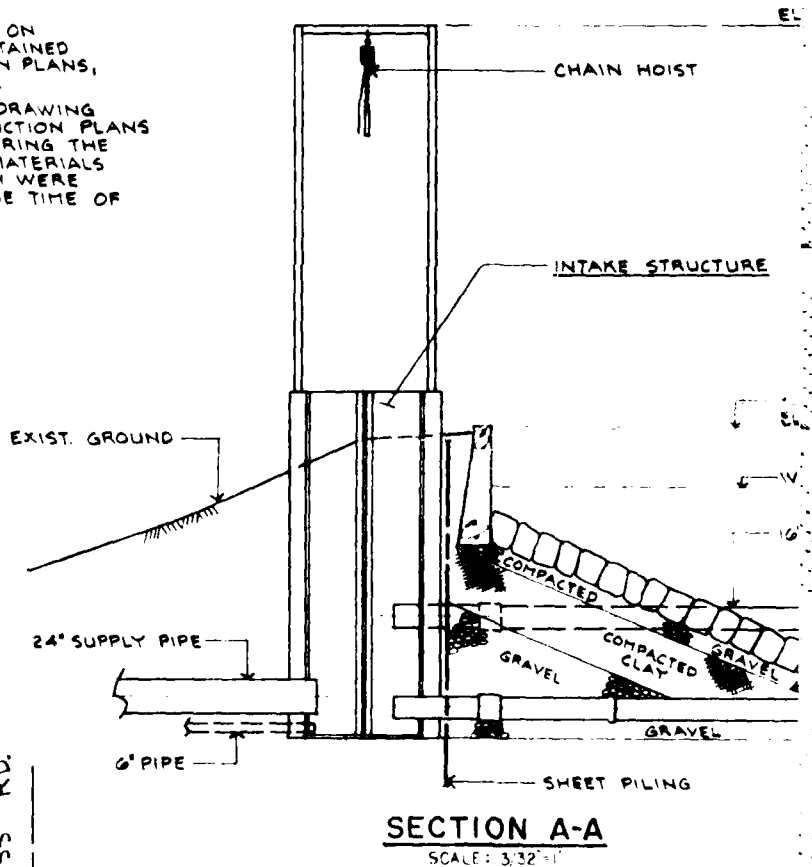
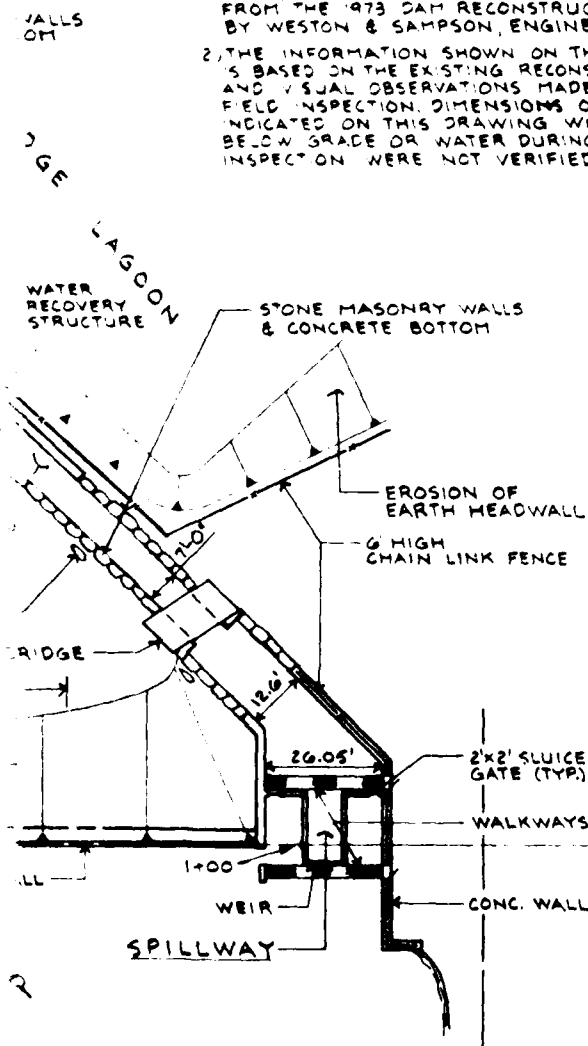
PLANS AND DETAILS



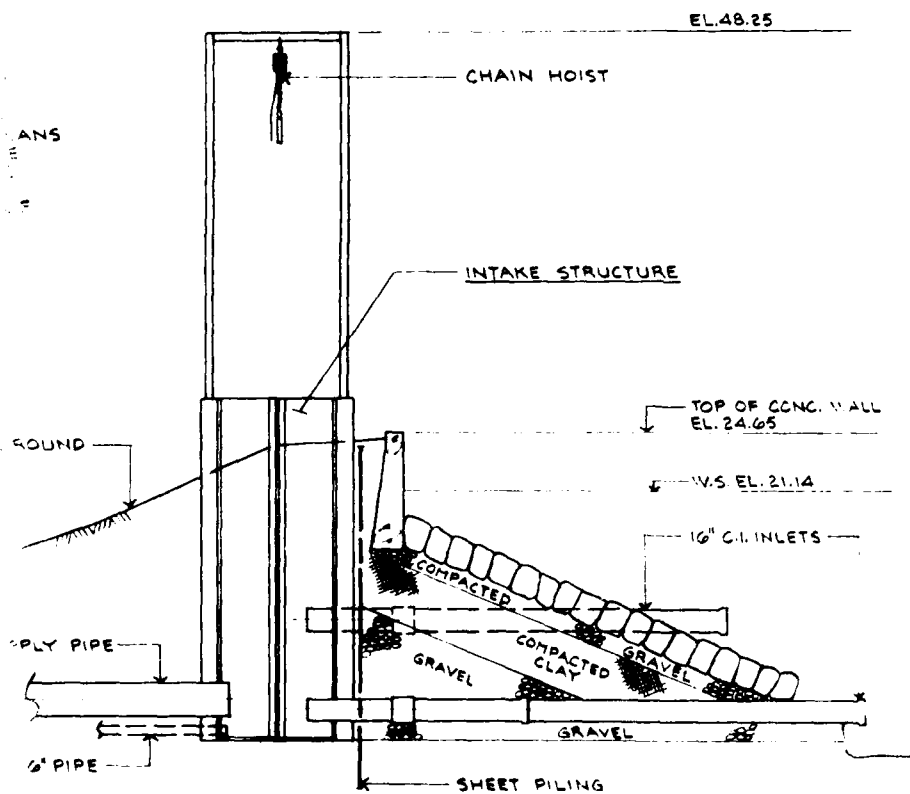
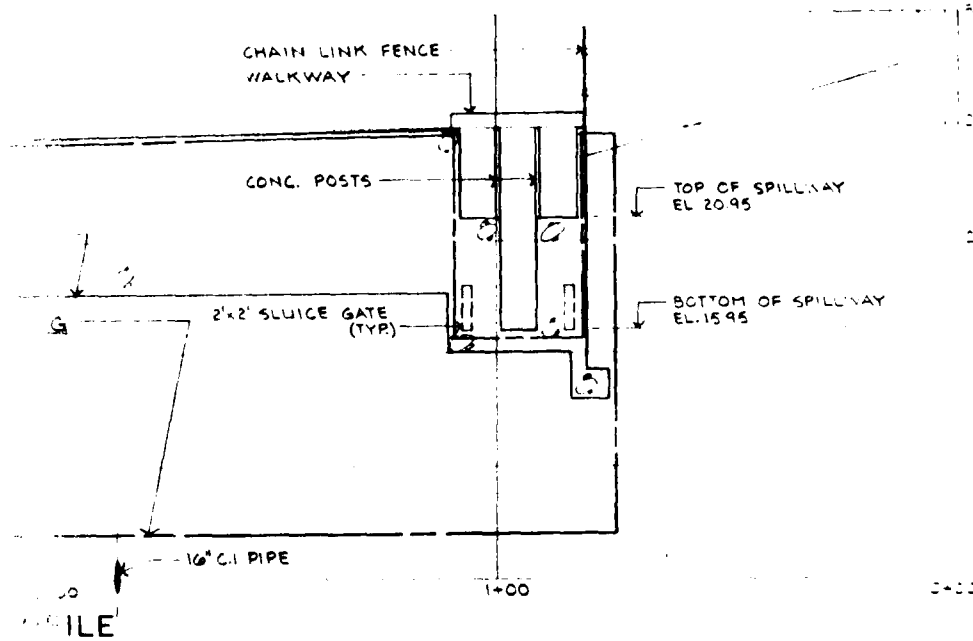


NOTES

1. THE ELEVATIONS SHOWN ARE BASE ON U.S.G.S. DATUM FROM INFORMATION OBTAINED FROM THE 1973 DAM RECONSTRUCTION PLANS, BY WESTON & SAMPSON, ENGINEER.
2. THE INFORMATION SHOWN ON THIS DRAWING IS BASED ON THE EXISTING RECONSTRUCTION PLANS AND VISUAL OBSERVATIONS MADE DURING THE FIELD INSPECTION. DIMENSIONS OR MATERIALS INDICATED ON THIS DRAWING WHICH WERE BELOW GRADE OR WATER DURING THE TIME OF INSPECTION WERE NOT VERIFIED.



SEA CONSULTANTS INC.	U.S. ARMY
DOCTOR, MA - ROXBOROUGH, NH	
NATIONAL PROGRAM OF INSP	
EXETER WORK'S	

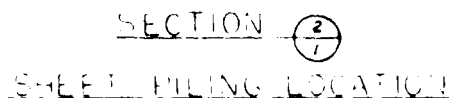
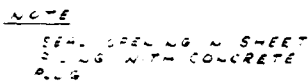


SECTION A-A

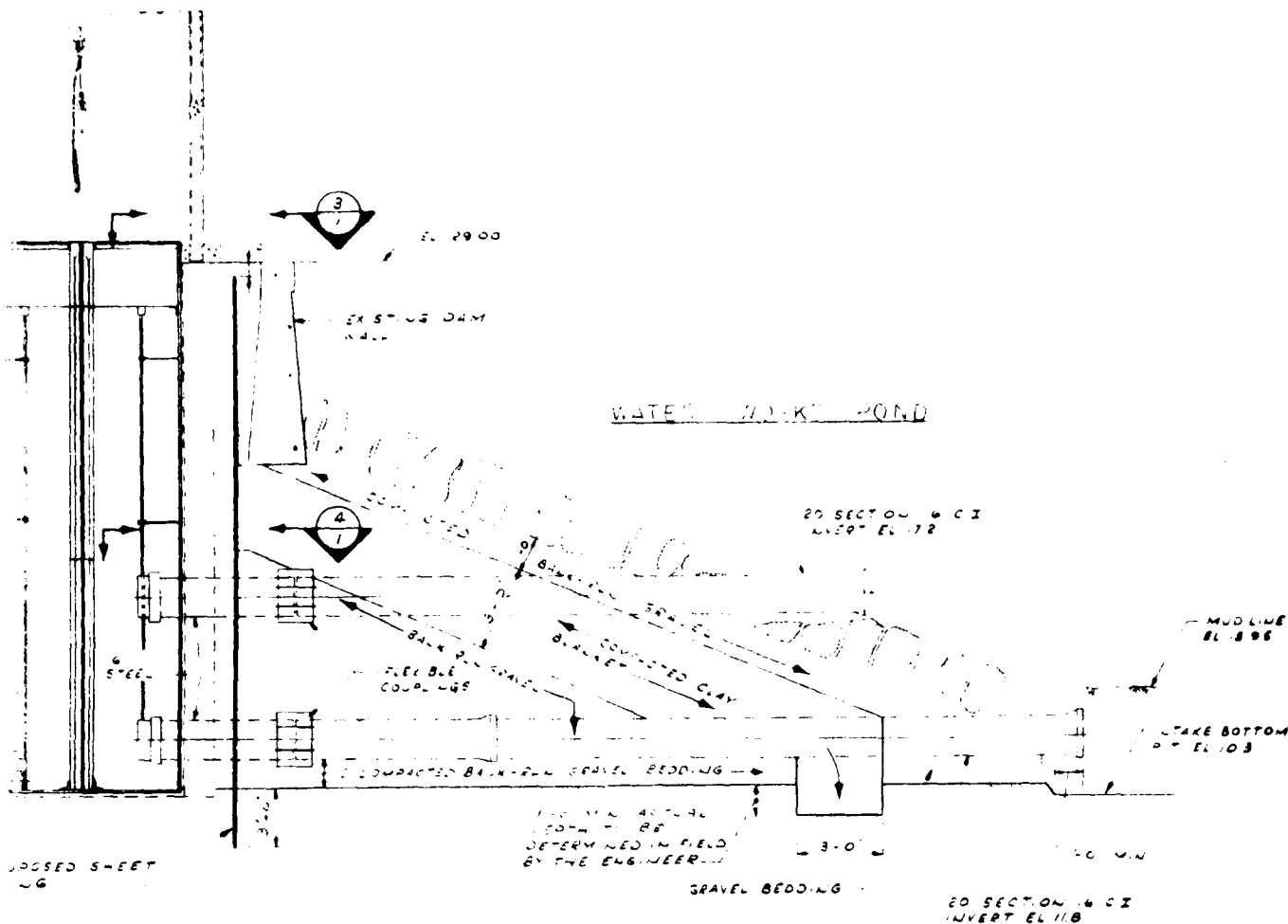
SCALE: 3/32" = 1'

SEA CONSULTANTS INC. BOSTON, MA - ROCHESTER, N.H.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS BALTIMORE, MD.
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	
EXETER WATER WORK'S DAM	
EXETER, NEW HAMPSHIRE	
SCALE AS NOTED DATE NOVEMBER 1975	

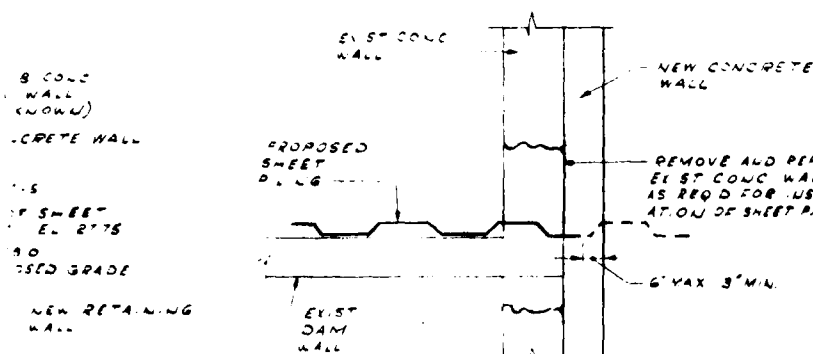
507
552 5-557 507
108 5200510
50 41 440
554 45



1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049 2050 2051 2052 2053 2054 2055 2056 2057 2058 2059 2060 2061 2062 2063 2064 2065 2066 2067 2068 2069 2070 2071 2072 2073 2074 2075 2076 2077 2078 2079 2080 2081 2082 2083 2084 2085 2086 2087 2088 2089 2090 2091 2092 2093 2094 2095 2096 2097 2098 2099 2100 2101 2102 2103 2104 2105 2106 2107 2108 2109 2110 2111 2112 2113 2114 2115 2116 2117 2118 2119 2120 2121 2122 2123 2124 2125 2126 2127 2128 2129 2130 2131 2132 2133 2134 2135 2136 2137 2138 2139 2140 2141 2142 2143 2144 2145 2146 2147 2148 2149 2150 2151 2152 2153 2154 2155 2156 2157 2158 2159 2160 2161 2162 2163 2164 2165 2166 2167 2168 2169 2170 2171 2172 2173 2174 2175 2176 2177 2178 2179 2180 2181 2182 2183 2184 2185 2186 2187 2188 2189 2190 2191 2192 2193 2194 2195 2196 2197 2198 2199 2200 2201 2202 2203 2204 2205 2206 2207 2208 2209 2210 2211 2212 2213 2214 2215 2216 2217 2218 2219 2220 2221 2222 2223 2224 2225 2226 2227 2228 2229 2230 2231 2232 2233 2234 2235 2236 2237 2238 2239 2240 2241 2242 2243 2244 2245 2246 2247 2248 2249 2250 2251 2252 2253 2254 2255 2256 2257 2258 2259 2260 2261 2262 2263 2264 2265 2266 2267 2268 2269 2270 2271 2272 2273 2274 2275 2276 2277 2278 2279 2280 2281 2282 2283 2284 2285 2286 2287 2288 2289 2290 2291 2292 2293 2294 2295 2296 2297 2298 2299 2300 2301 2302 2303 2304 2305 2306 2307 2308 2309 2310 2311 2312 2313 2314 2315 2316 2317 2318 2319 2320 2321 2322 2323 2324 2325 2326 2327 2328 2329 2330 2331 2332 2333 2334 2335 2336 2337 2338 2339 2340 2341 2342 2343 2344 2345 2346 2347 2348 2349 2350 2351 2352 2353 2354 2355 2356 2357 2358 2359 2360 2361 2362 2363 2364 2365 2366 2367 2368 2369 2370 2371 2372 2373 2374 2375 2376 2377 2378 2379 2380 2381 2382 2383 2384 2385 2386 2387 2388 2389 2390 2391 2392 2393 2394 2395 2396 2397 2398 2399 2400 2401 2402 2403 2404 2405 2406 2407 2408 2409 2410 2411 2412 2413 2414 2415 2416 2417 2418 2419 2420 2421 2422 2423 2424 2425 2426 2427 2428 2429 2430 2431 2432 2433 2434 2435 2436 2437 2438 2439 2440 2441 2442 2443 2444 2445 2446 2447 2448 2449 2450 2451 2452 2453 2454 2455 2456 2457 2458 2459 2460 2461 2462 2463 2464 2465 2466 2467 2468 2469 2470 2471 2472 2473 2474 2475 2476 2477 2478 2479 2480 2481 2482 2483 2484 2485 2486 2487 2488 2489 2490 2491 2492 2493 2494 2495 2496 2497 2498 2499 2500 2501 2502 2503 2504 2505 2506 2507 2508 2509 2510 2511 2512 2513 2514 2515 2516 2517 2518 2519 2520 2521 2522 2523 2524 2525 2526 2527 2528 2529 2530 2531 2532 2533 2534 2535 2536 2537 2538 2539 2540 2541 2542 2543 2544 2545 2546 2547 2548 2549 2550 2551 2552 2553 2554 2555 2556 2557 2558 2559 2560 2561 2562 2563 2564 2565 2566 2567 2568 2569 2570 2571 2572 2573 2574 2575 2576 2577 2578 2579 2580 2581 2582 2583 2584 2585 2586 2587 2588 2589 2590 2591 2592 2593 2594 2595 2596 2597 2598 2599 2600 2601 2602 2603 2604 2605 2606 2607 2608 2609 2610 2611 2612 2613 2614 2615 2616 2617 2618 2619 2620 2621 2622 2623 2624 2625 2626 2627 2628 2629 2630 2631 2632 2633 2634 2635 2636 2637 2638 2639 2640 2641 2642 2643 2644 2645 2646 2647 2648 2649 2650 2651 2652 2653 2654 2655 2656 2657 2658 2659 2660 2661 2662 2663 2664 2665 2666 2667 2668 2669 2670 2671 2672 2673 2674 2675 2676 2677 2678 2679 2680 2681 2682 2683 2684 2685 2686 2687 2688 2689 2690 2691 2692 2693 2694 2695 2696 2697 2698 2699 2700 2701 2702 2703 2704 2705 2706 2707 2708 2709 2710 2711 2712 2713 2714 2715 2716 2717 2718 2719 2720 2721 2722 2723 2724 2725 2726 2727 2728 2729 2730 2731 2732 2733 2734 2735 2736 2737 2738 2739 2740 2741 2742 2743 2744 2745 2746 2747 2748 2749 2750 2751 2752 2753 2754 2755 2756 2757 2758 2759 2760 2761 2762 2763 2764 2765 2766 2767 2768 2769 2770 2771 2772 2773 2774 2775 2776 2777 2778 2779 2780 2781 2782 2783 2784 2785 2786 2787 2788 2789 2790 2791 2792 2793 2794 2795 2796 2797 2798 2799 2800 2801 2802 2803 2804 2805



SECTION 1/1
INTAKE STRUCTURE RENOVATIONS
SCALE 3/4" = 1'-0"



NOTES

- BACKFILLING OF ALL EXCAVATED AREAS WITHIN THE LIMITS OF THE DAM EMBANKMENTS SHALL BE THOROUGHLY COMPACTED IN LAYERS NOT EXCEEDING 6 INCHES IN DEPTH AND SHALL OBTAIN THE PERCENTAGE OF COMPACTION STATED IN P. 96 OF THE SPECIFICATIONS.
- STEEL PIPES TO BE REPAINTED WITH COATINGS SPECIFIED AFTER ALL WELDING HAS BEEN COMPLETED.
- HAND RUN GRAVEL SHALL BE AS SPECIFIED.
- ALL PIPES SHOWN ARE TO BE INSTALLED UNDER THE ORIGINAL WORK. INSTALLATION TO BE DONE AFTER THE SHEET PILING HAS BEEN DRIVEN. HOLES SHALL BE CUT IN THE PILING TO RECEIVE ALL PIPES.

TOWN OF EXETER, NEW HAMPSHIRE.

WATER DEPARTMENT

WATER TREATMENT PLANT AND APPURTENANT WORK

DAM RESTORATION

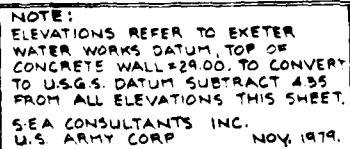
PROPOSED SHEET PILING & DETAILS

NOTE: ELEVATIONS REFER TO EXETER WATER WORKS DATUM. TOP OF CONCRETE WALLS 29.00. TO CONVERT TO USGS. DATUM SUBTRACT 4.55 FROM ALL ELEVATIONS THIS SHEET.
S.E.A. CONSULTANTS INC.
U.S. ARMY CORP. NOV. 1979

ADDED NEW CONCRETE WALL			
DESIGNED BY	3/18/79	CHECKED BY	APPROVED BY
APPROVED BY			
FOR: WESTON & SAMPSON, ENGINEERS			
DESIGNED BY	DATE	CHECKED BY	DATE



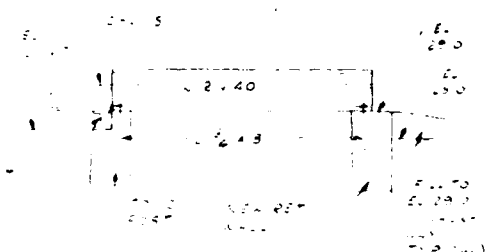
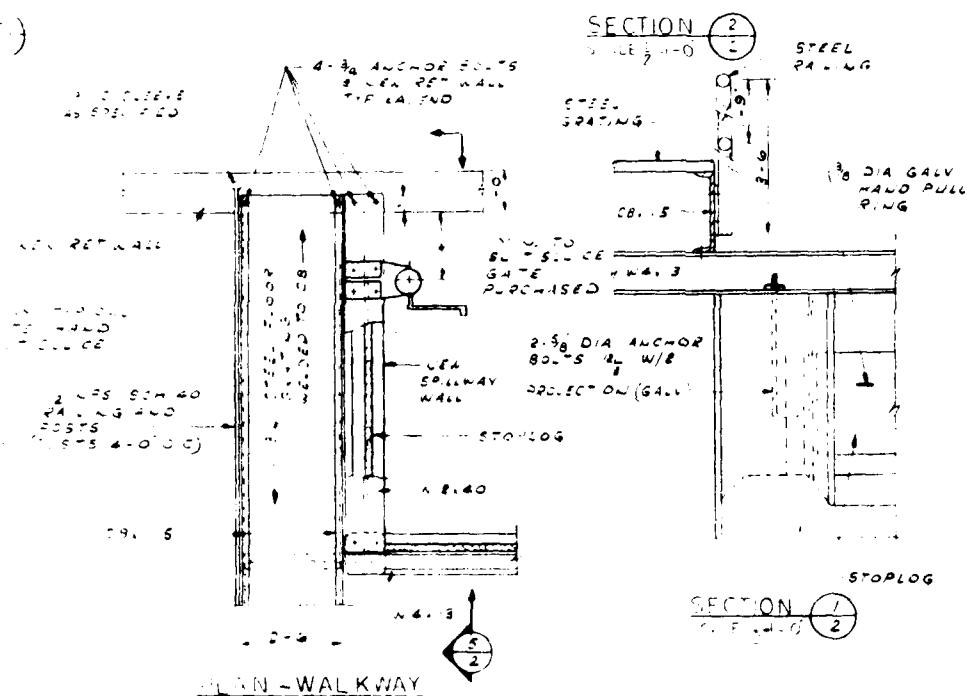
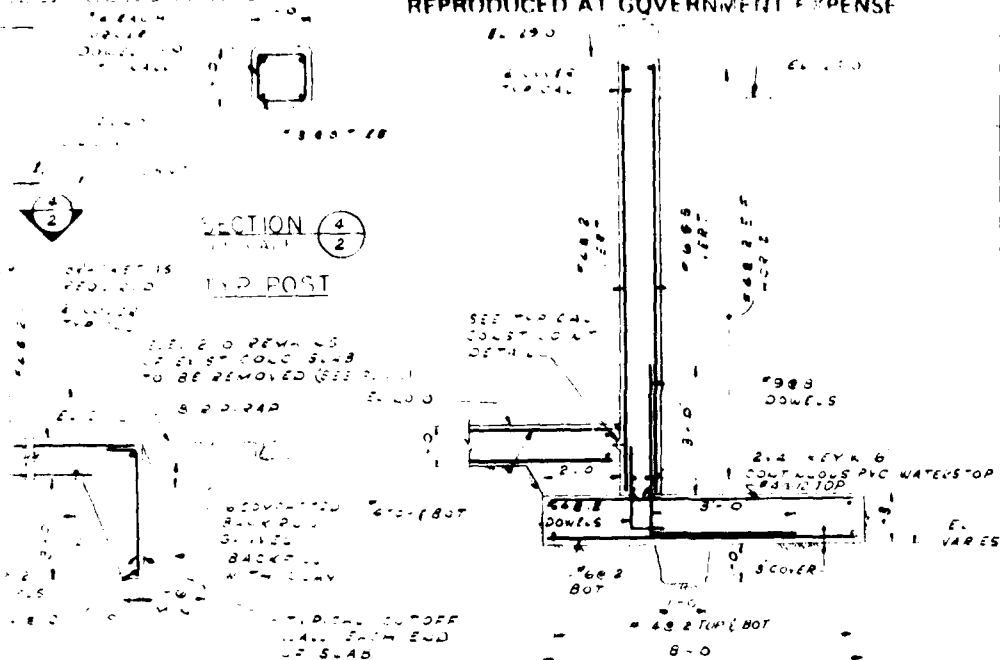
DRAWN BY ERD	WESTON & SAMPSON ENGINEERS		
CHECKED BY C.A.B.	10 HIGH STREET	BOSTON, MASS.	
DATE	SCALE AS SHOWN	DATE OCT. 1973	
APPROVED BY JAP	SHEET 1 OF 2 SHEETS	29-110	



NOTE:
ELEVATIONS REFER TO EXETER
WATER WORKS DATUM, TOP OF
CONCRETE WALL = 29.00. TO CONVERT
TO U.S.G.S. DATUM SUBTRACT 4.35
FROM ALL ELEVATIONS THIS SHEET.

S.E.A CONSULTANTS INC.
U.S. ARMY CORP NOV. 1979.

2-211 (A)
E. 2

[illegible]

TOWN OF EXETER, NEW HAMPSHIRE

WATER DEPARTMENT

WATER TREATMENT PLANT AND
APPURTENANT WORK

DAM RESTORATION

PROPOSED SPILLWAY & DETAILS

—

WESTON & SAMPSON

ENGINEERS

10 HIGH STREET BOSTON, MASS.

APPROVED BY

SCALE AS SHOWN

DATE OCT 1973

2 of 2 SHEETS

9-118

BORING LOGS

BORING REPORT C. L. GUILD DRILLING & BORING CO., 'INC.

AREA CODE 617
848-3777

MAINTREE, MASS.

TO WESTON & SAMPSON, ENGINEERS DATE 29 AUGUST 1973
ADDRESS 10 HIGH STREET BOSTON, MASSACHUSETTS
SITE LOCATION PROPOSED DAM RESTORATION EXETER, NEW HAMPSHIRE
REPORT SENT TO ABOVE - ATTN - MR. PERKINS DATE 29 AUGUST 1973
SAMPLES SENT TO ABOVE - ATTN - MR. PERKINS DATE 29 AUGUST 1973

BORING LOCATION DRAWING TO BE FURNISHED

BY

OTHERS

B-18

BORING REPORT C. L. GUILD DRILLING & BORING CO., INC. BORING REPORT
 BRAintree, MASS.

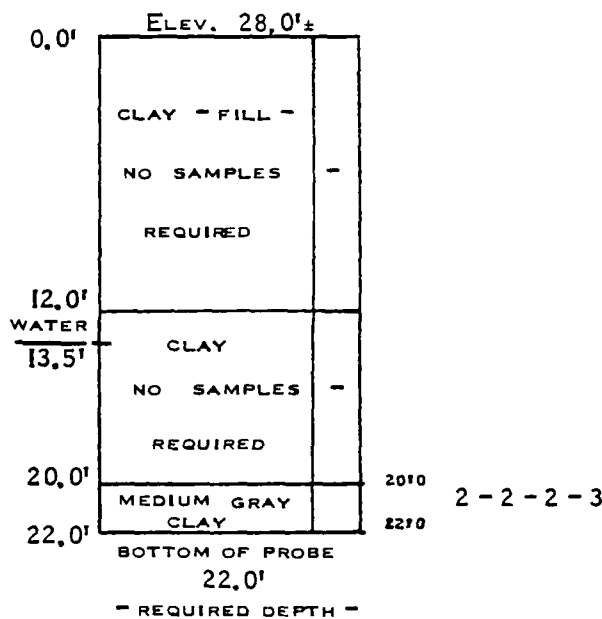
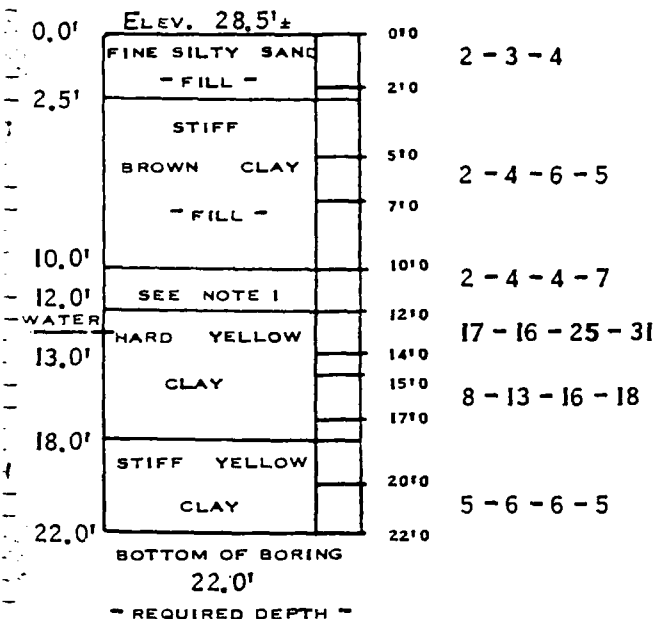
TO WESTON & SAMPSON BOSTON, MASSACHUSETTS
 SITE LOCATION PROPOSED DAM RESTORATION EXETER, NEW HAMPSHIRE
 SCALE 1" = 8 FT. REFERENCE DATUM FURNISHED BY ABOVE

BORING NO. 101

BORING NO. _____

PROBE
 BORING NO. S-1

BORING NO. _____



NOTE 1 - STIFF YELLOW CLAY TRACE OF PEAT.

NOTE - USED 2-1/2" CASING & AW RODS

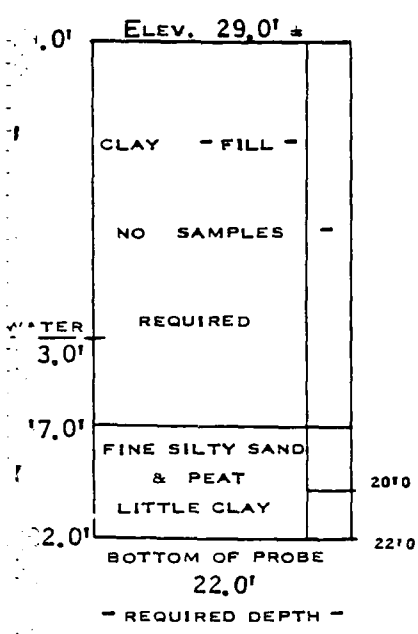
8 - 21 - 73

8 - 21 - 73

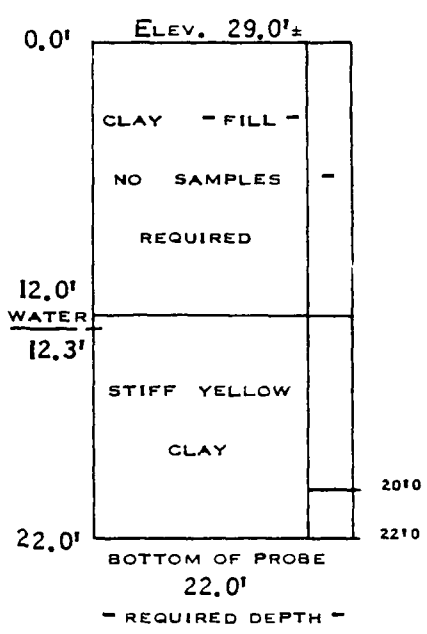
*INDICATES MUD LOST IN THIS LAYER OF SOIL FOOTAGE OF BORING THIS SHEET 44.0'
 WATER READING INDICATES SURFACE OF WATER AT COMPLETION OF BORING UNLESS NOTED OTHERWISE. FIGURES IN LOG COLUMN INDICATE
 NUMBER OF BLOWS TO DRIVE 2" SPLIT SAMPLER 6 INCHES WITH 140 LB. WEIGHT FALLING 30 INCHES UNLESS OTHERWISE SPECIFIED.
 SHEET 2 OF 4 FOREMAN DP CLASSIFICATION BY DP & RVB RB JOB NO. 43056

BORING REPORT **C. L. GUILD DRILLING & BORING CO., INC.** BORING REPORT
 BRAINTREE, MASS.

TO WESTON & SAMPSON BOSTON, MASSACHUSETTS
 SITE LOCATION PROPOSED DAM RESTORATION EXETER, NEW HAMPSHIRE
 SCALE 1" = 8 FT. REFERENCE DATUM FURNISHED BY ABOVE
 PROBE BORING NO. S-3 BORING NO. PROBE BORING NO. S-4 BORING NO.



1-1-1-2



4-7-7-6

8 - 22 - 73

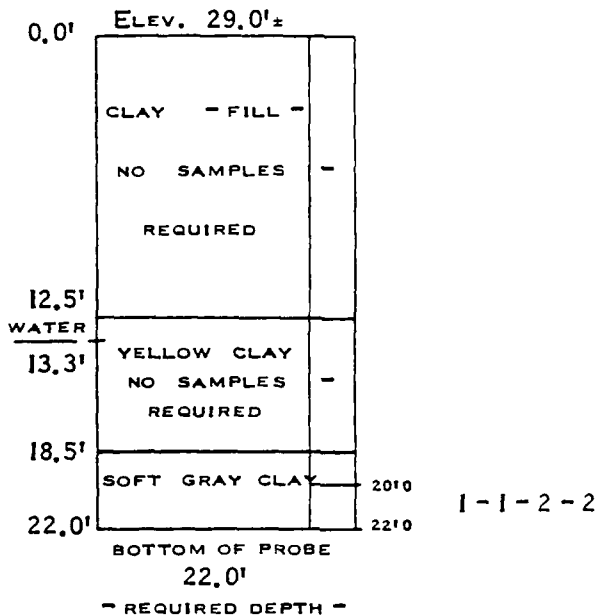
8 - 22 - 73

BORING REPORT C. L. GUILD DRILLING & BORING CO., INC. BORING REPO

BRAINTREE, MASS.

TO WESTON & SAMPSON BOSTON, MASSACHUSETTS
 SITE LOCATION PROPOSED DAM RESTORATION EXETER, NEW HAMPSHIRE
 SCALE 1" = 8 FT. REFERENCE DATUM FURNISHED BY ABOVE

BORING NO. PROBE BORING NO. S-5 BORING NO. BORING NO.



8 - 22 - 73

*INDICATES MUD LOST IN THIS LAYER OF SOIL FOOTAGE OF BORING THIS SHEET 22.0'
 WATER READING INDICATES SURFACE OF WATER AT COMPLETION OF BORING UNLESS NOTED OTHERWISE FIGURES IN LOG COLUMN INDIC
 NUMBER OF BLOWS TO DRIVE 2" SPLIT SAMPLER 6 INCHES WITH 140 LB. WEIGHT FALLING 30 INCHES UNLESS OTHERWISE SPECI
 SHEET 4 OF 4 FOREMAN DP CLASSIFICATION BY DP - RVB RB JOB NO. 43056

APPENDIX C

SELECTED PHOTOGRAPHS

EXETER WATER
WORKS DAM
PHOTO INDEX

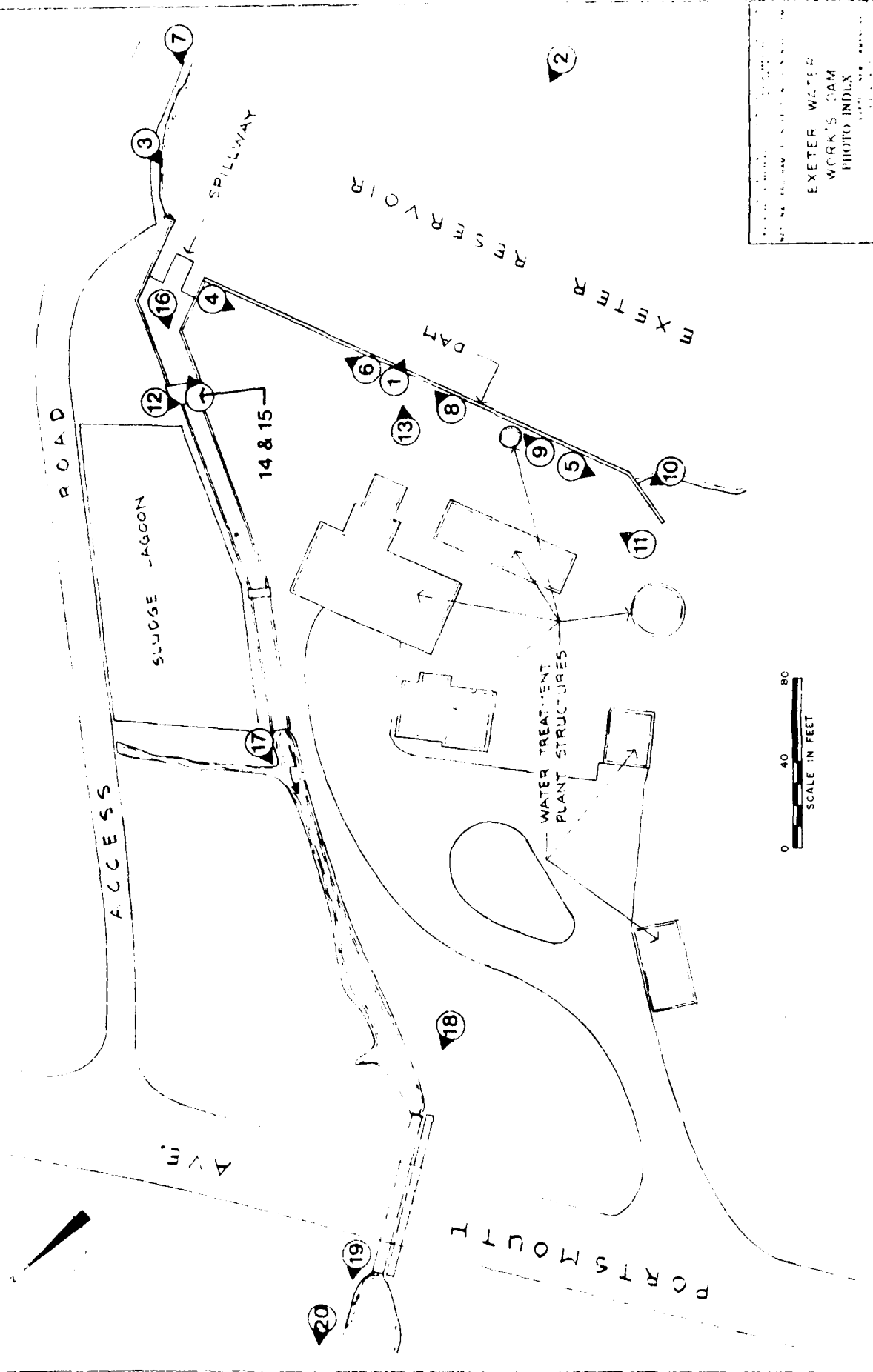
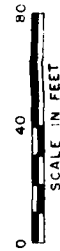




Photo No. 1 - General view of reservoir from
center of dam.



Photo No. 2 - General view of dam from reservoir.



Photo No. 5 - View of left abutment from dam.

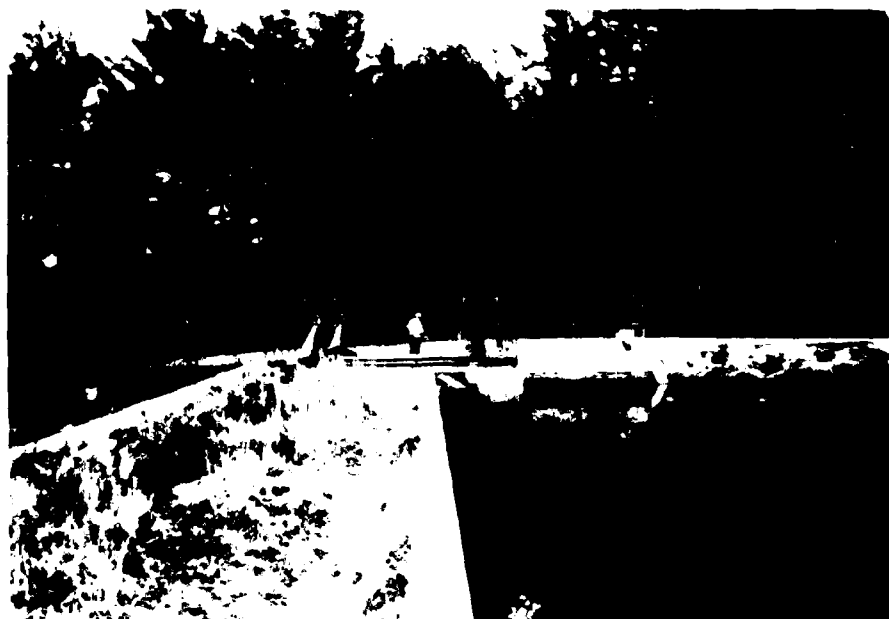


Photo No. 6 - View of spillway and right
abutment from center of dam.

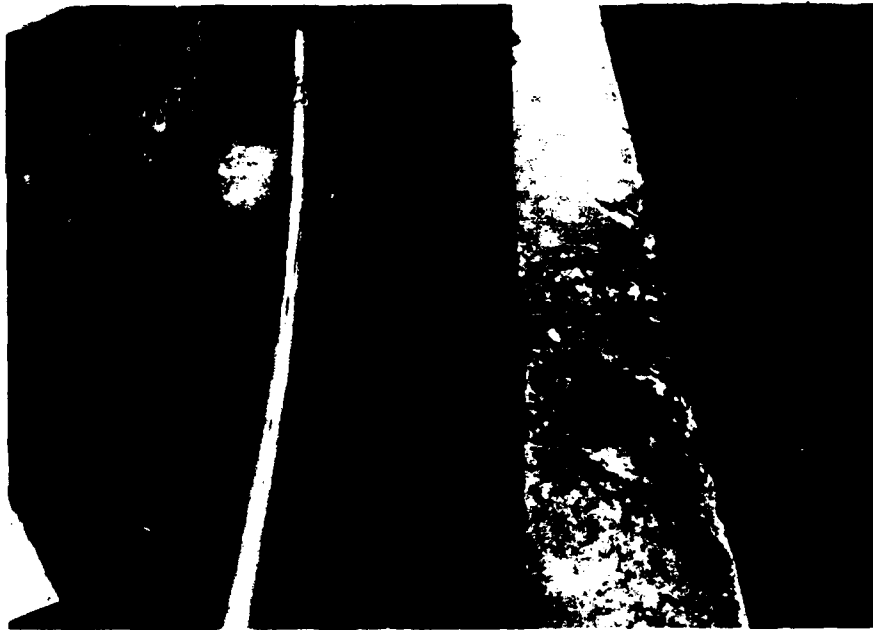


Photo No. 9 - Subsidence of fill along dam crest
at water works inlet structure
(STA. 2+70).

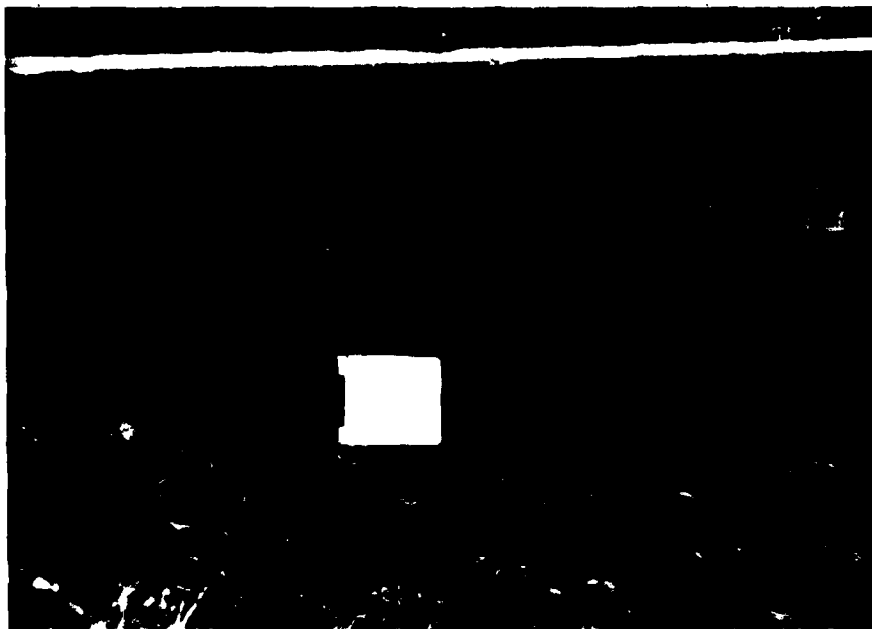


Photo No. 10 - Crack in concrete face wall near
left abutment (STA. 3+39).

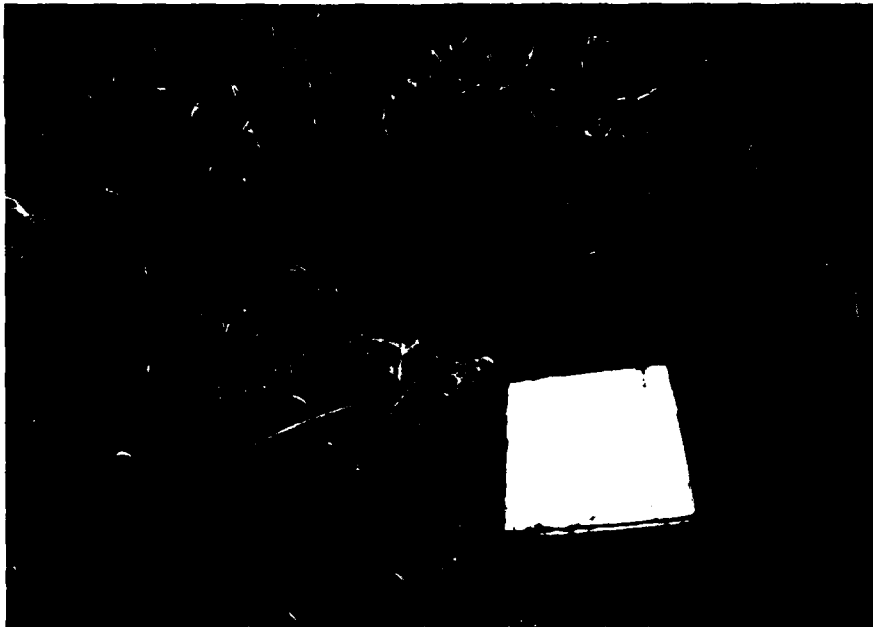


Photo No. 13 - Woodchuck hole in downstream slope
at STA. 2+16 about 5 feet below crest.



Photo No. 14 - View of spillway structure looking
upstream from spillway discharge
channel.



Photo No. 17 - View looking downstream toward roadway culverts from end of spillway discharge channel.



Photo No. 18 - Closeup of roadway culverts (upstream invert).

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

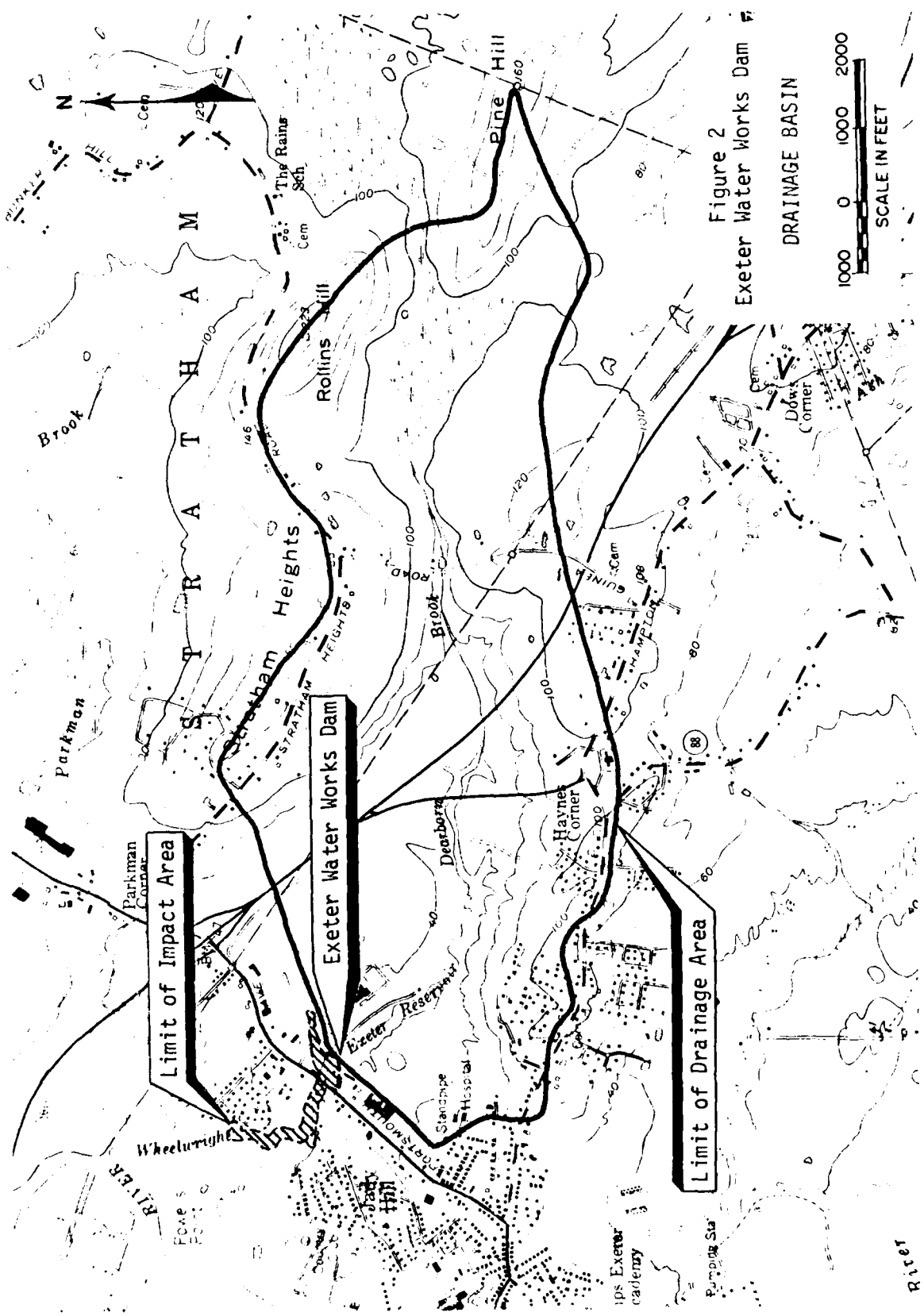


Figure 2
Exeter Water Works Dam

DRAINAGE BASIN

1000 0 1000 2000
SCALE IN FEET

CLIENT Frank S. Gage

JOB NO. 134-2901

PAGE 1 of 23

PROJECT Franklin Dam, New York

COMPTD. BY SLP

DATE 12/13/89

DETAIL Site Map, 1:25,000

CK'D. BY KMD

DATE 1/25/90

I. Basic Data

A Drainage Area

- 1.8 square miles - as defined on U.S.G.S. map and then planimetered
- drainage area would classify as 10.0 sq. mi. for estimating MPF Peak Flow Rates

B. Dam and Storage Information

- Size Classification: SMALL (<1000 Acre-ft and <500 ft)

a. Elev. Top of Dam = 24.65 ft

Elev. Pond Bottom = 9.60 ft

(per Drawing - Mud Line)

15.05 ft

- b Estimated surface area of pond at dam crest
≈ 26 acres

c. Storage (Acre-feet)

(1) Total storage = storage between pond bottom and spillway weir crest plus storage between weir crest to dam crest

$$\text{Storage} = \left(\frac{0+9.2}{2} \right) (20.95-9.6) + \left(\frac{26+9.2}{2} \right) (24.65-20.95) = 117 \text{ Acre-ft}$$

- Hazard Potential: HIGH

1. Failure of dam could result in extensive damage to Franklin Water Treatment Plant and loss of water to many homes and businesses working therein.

N.H. Title 108

CLIENT State of New Hampshire JOB No. 224-283 PAGE 2 of 22
PROJECT Flood Control District COMPTD. BY J. J. J. DATE 2-2-84
DETAIL Hydrology & Sedimentation CK'D. BY A. J. J. DATE 2-2-84

3 Storage Information

Descriptive Information	Elevation, *	Surface Area*	Volume
Crest of dam (concrete wall)	24.65	26	117
Top of stoplogs	22.95	13	79
Permanent spillway weir	20.95	4.2	52
Invert spillway Gates	15.45	5.1	16
Elevation of mud line (per drawings)	9.60	0	0

- * Notes: (1) Elevations - USGS datum (NGVD)
(2) Surface area is based on:
(a) normal pool elevation taken at permanent spillway crest and it was assumed that the pool would be at that elevation at the crest.
(b) surface area at top of stoplogs determined by assuming a crest elevation of 24.65 compared to 22.95 at the pond surface and the 40 feet width.
(c) Surface area associated with stoplogs is the area between permanent spillway crest and crest of stoplogs.

C. Spillway Information

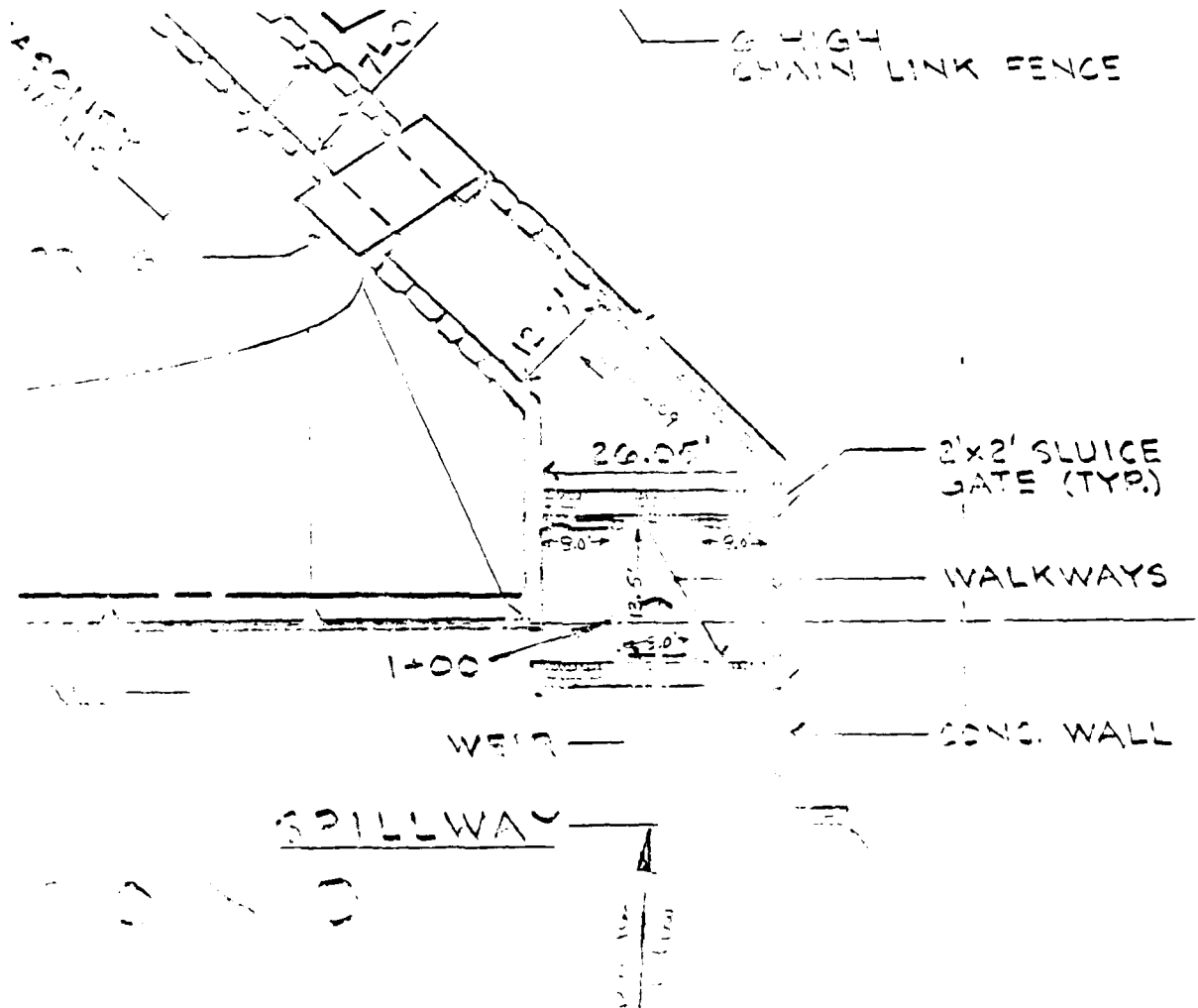
Channel is concrete wall with 12' high concrete

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CLIENT <u>Frank Jones</u>	JOB NO. <u>274-780</u>	PAGE <u>3 of 32</u>
PROJECT <u>Water Pollution Control</u>	COMPTD. BY <u>BWP</u>	DATE <u>2/15/78</u>
DETAIL <u>Spillway</u>	CK'D. BY <u>WJS</u>	DATE <u>2/15/78</u>

2 Spillway plan



a row a set of wires which can be interlocked together. It is assumed that the set of wires will have a constant head. The wires may be used in a number of ways. It is assumed that the wires will be used in a number of ways.

Drawn by J. J. Jones
Checked by W. J. Jones

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CLIENT City of Rochester
PROJECT Water Pollution Control
DETAIL Design of Weir

JOB No. 254-270 PAGE 1
COMPTD. BY TE DATE 11/1/71
CK'D. BY TE DATE 11/1/71

L = crest length of weir
 H = head on weir

(b) If $L > 2.5 \frac{H}{P}$

$$C = 3.27 + 0.40 \frac{H}{P}$$

where H = head on weir
 P = weir height

(c) If weir width $<$ approach channel width, the effective weir width, L , is

$$L = L' - 0.2 N$$

where L' = crest length
 N = number of abutments
 H = head on weir

I will apply the coefficient for weir as intermediate between estimating discharge

II. Estimate surcharge storage on maximum discharge

A. Develop Stage - discharge curve for outfall from dam

1. define sources of outflow

a. Spillway - assume stop logs in place (normal operating procedure) and remain intact during flood. Use standard stage discharge curve.

b. at El 23.67 water will begin to pass over spillway into lower stream bed.

most of the water will be lost to the lower stream bed.

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CLIENT Lowell Dam JOB NO. 274-790 PAGE 5 of 5
PROJECT Lowell Dam COMPTD. BY P. J. DATE 2-2-79
DETAIL Spillway CK'D. BY P. J. DATE 2-2-79

(Standard Handbook for CE's, 1977)

C. at El 24.65 the dam crest will be 100 ft wide and the spillway dam will be 100 ft wide. The broad crest will be 100 ft wide.

2. Spillway Outflow

Elevation	C	Elevation L (ft)	H (ft)	Q (cfs)
22.95	—	—	0.0	0.0
23.0	3.273	50.2	0.05	1.8
24.0	3.330	—	1.05	130
25.0	3.387	—	2.05	444
26.0	3.444	—	3.05	921
27.0	3.501	—	4.05	1480
28.0	3.559	—	5.05	2030
29.0	3.616	—	6.05	2700
30.0	3.673	—	7.05	3450

3. Flow of the Spillway = 30' crest

Elevation	C	L (ft)	H (ft)	Q (cfs)
23.65	—	—	—	—
24.0	2.60	3	0.33	3.0
25.0	—	23	1.33	42
26.0	—	42	2.33	142
27.0	—	59	3.33	312
28.0	—	72	4.33	512
29.0	—	84	5.33	742
30.0	—	96	6.33	1002

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CLIENT Army Corps

JOB NO. 274-7901

PAGE 6 of 22

PROJECT Egypt Water Works Dam

COMPTD. BY BWP

DATE 2/19/79

DETAIL Hydrologic Calc

CK'D. BY 2/19/79

DATE 2/19/79

4 Flow over dam (assuming all overflows at crest)

Elevation	Q	L (ft)	h (ft)	Q (cfs)
24.65	—	—	—	—
25.0	2.54	222	.35	117
26.0	2.66	269	1.35	1120
27.0	2.65	272	2.35	2600
28.0	2.66	275	3.35	4490
29.0	2.68	276	4.35	6710
30.0	2.74	277	5.35	9390

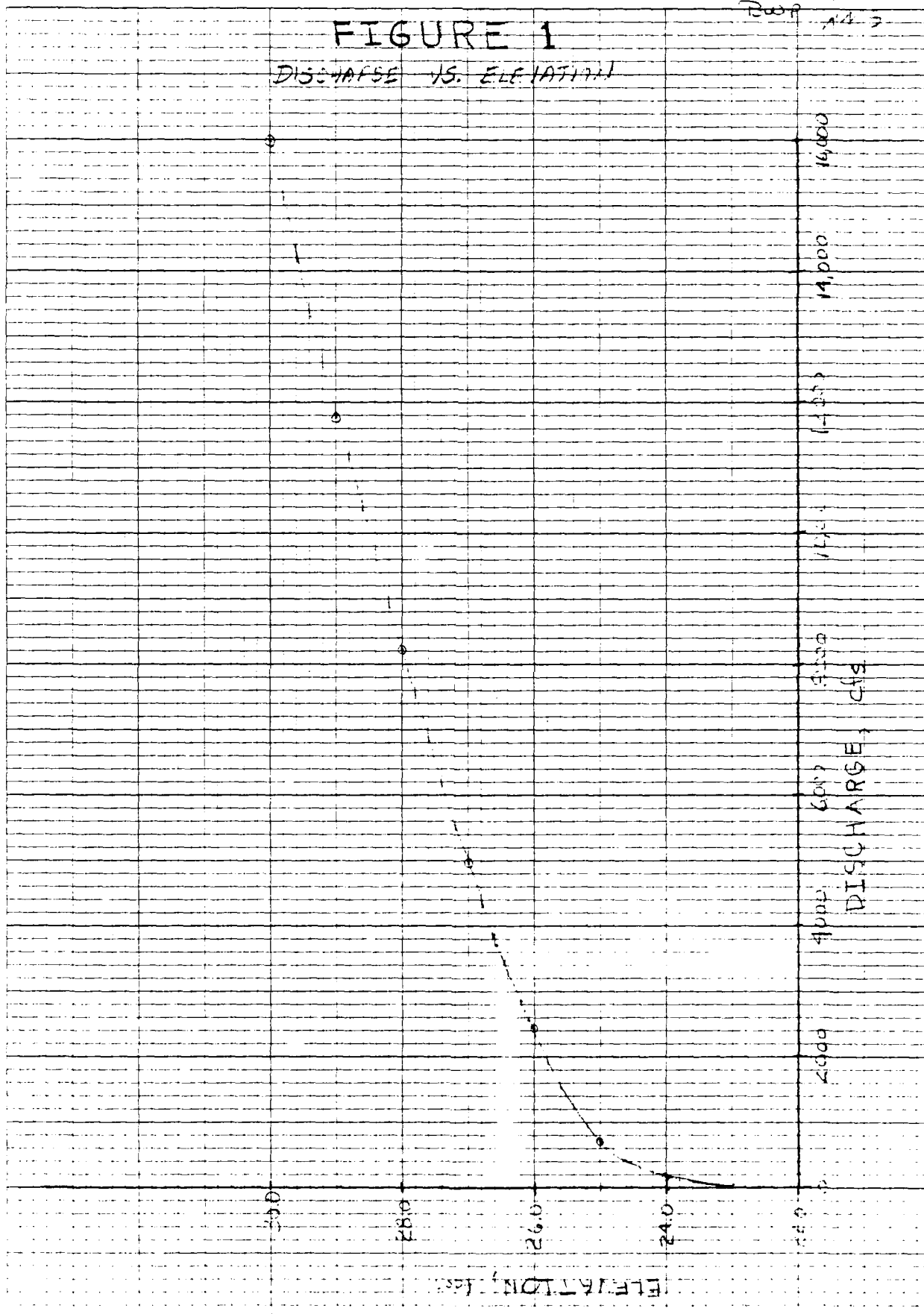
5 Total outflow

Elevation	Q Spillway	Q by channel	Q can	Q TOTAL
22.95	0.0	0.0	0.0	0.0
23.0	1.8	0.0	0.0	1.8
24.0	180	3.0	0.0	183
25.0	499	92	117	705
26.0	921	333	1120	2429
27.0	1430	932	2600	4962
28.0	2030	1690	4490	8210
29.0	2700	2370	6710	11780
30.0	3450	3150	9390	15990

Information in table shown graphically in
Figure 1

FIGURE 1

DISCHARGE VS. ELEVATION



CLIENT Army Corps JOB No. 274-7901 PAGE 3 of 22
PROJECT Exeter Water Works Dam COMPTD. BY BWP DATE 12/1/77
DETAIL Hydrologic Calcs CK'D. BY AKM DATE 1/1/78

B. Effect of Surcharge Storage on Max Probable Flood

1. Pertinent Data

- (1) Drainage area = 1.8 Square miles
- (2) characteristics of basin - rolling
- (3) test flood - PMF (small size and high hazard)
- (4) follow Army Corps' procedure

2. STEP 1: Determine Peak Inflow (Q_{P1}) from Guide Curves

a. extrapolating from Guide Curve the maximum probable flood was estimated at 2150 cfs/sq. mi.

$$\therefore \text{Max Prob Flood} = (2150 \text{ cfs/sq. mi.}) (1.8 \text{ sq. mi.})$$

$$= 3870 \text{ cfs}$$

3. STEP 2: Determine Surcharge Height to Pass Q_{P1} , $STOR_1$, and Q_{P2}

- a. from Figure 1 determine Surcharge height to pass $Q_{P1} = 3870 \text{ cfs}$.

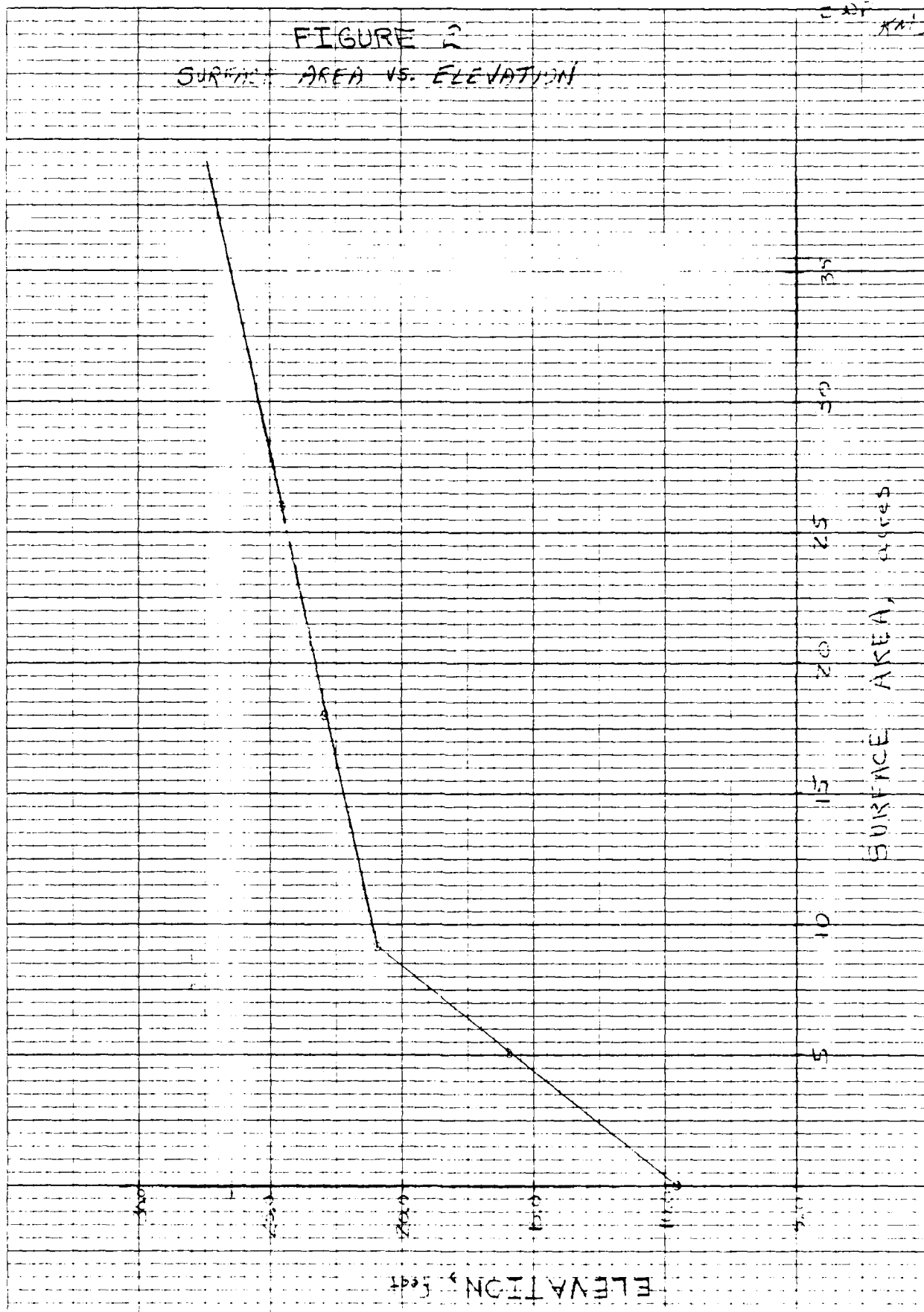
$$\begin{aligned} \text{Surcharge Elev.} &= 20.65 \text{ feet} \\ \text{Spillway - stoplog Elev.} &= 22.95 \text{ feet} \\ &= 3.70 \text{ feet} \end{aligned}$$

- b. determine Volume of Surcharge ($STOR_1$) in inches of runoff

- (1) use average Pond area between spillway crest elev and surcharge elev (see Figure 2) to determine Storage.

$$\begin{aligned} STOR_1 &= \frac{\text{Volume of Storage (in acre-feet)}}{\text{drainage area}} \\ &= \frac{\left(\frac{18 + 36.2}{2} \text{ acres} \right) (3.70 \text{ feet}) (12 \text{ inches/foot})}{(1.8 \text{ sq. mi.}) (640 \text{ acres/sq. mi.})} \end{aligned}$$

FIGURE 2
SURFACE AREA VS. ELEVATION



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PROJECT Exeter Water Works Dam COMPTD. BY BWP DATE 12/19/79
DETAIL Hydrologic Calcs CK'D. BY VHJ DATE 2/5/80

$$STOR_1 = 1.04 \text{ inches}$$

c. determine Q_{P2}

$$\begin{aligned} Q_{P2} &= Q_{P1} \left(1 - \frac{STOR_1}{19} \right) \\ &= (3870 \text{ cfs}) \left(1 - \frac{1.04}{19} \right) \\ &= 3658 \text{ cfs} \end{aligned}$$

4. STEP 3: Determine Surchage height and $STOR_2$
To Pass Q_{P2} and then Q_{P3}

a. from Figure 1 determine surcharge height to pass
 $Q_{P2} = 3658 \text{ fs}$

$$\begin{aligned} \text{Surcharge elev} &= 26.55 \text{ feet} \\ \text{Spillway - stoplog elev} &= 22.95 \text{ feet} \\ &= 3.60 \text{ feet} \end{aligned}$$

b. determine $STOR_2$

$$\begin{aligned} STOR_2 &= \frac{\left(\frac{35.5 + 13. \text{ acres}}{2} \right) (3.60 \text{ feet}) (12 \text{ inches/feet})}{(1.8 \text{ sq. mi}) (640 \text{ acres/sq. in})} \\ &= 1.00 \text{ inches} \end{aligned}$$

c. Average $STOR_1$ and $STOR_2$

$$\begin{aligned} STOR_{AVG 1-2} &= \frac{STOR_1 + STOR_2}{2} \\ &= \frac{1.04 \text{ in} + 1.00 \text{ in}}{2} \end{aligned}$$

$$STOR_{AVG 1-2} = 1.02 \text{ inches}$$

d. determine Q_{P3}

$$Q_{P3} = (3870 \text{ cfs}) \left(1 - \frac{1.02}{19} \right)$$

CLIENT Army Corps JOB NO. 274-790 PAGE 11 of 22
PROJECT Fry's Water Works Dam COMPTD. BY BWP DATE 12/19/79
DETAIL Hydrologic Calcs. CK'D. BY KNS DATE 12/21/79

$$Q_{P3} = 3662 \text{ cfs}$$

5. STEP 4: Determine surcharge height for Q_{P3} and $STOR_3$

a. from Figure 1 surcharge height for $Q_{P3} = 3662 \text{ cfs}$

$$\begin{aligned} \text{Surcharge elev} &\approx 26.55 \text{ feet} \\ \text{Spillway-stopping elev} &= \frac{22.95}{3.60} \text{ feet} \end{aligned}$$

b. determine $STOR_3$

$$\begin{aligned} STOR_3 &= \frac{\left(\frac{18 + 35.5}{2} \text{ acres}\right) (3.60 \text{ ft}) (1.2 \text{ ft})}{(1.8 \text{ sq.m.}) (640 \text{ ac/sq.m.})} \\ &= 1.00 \text{ inches} \end{aligned}$$

c. determine $STOR_{AVG}$

$$\begin{aligned} STOR_{AVG} &= \frac{1.00 \text{ in} + 1.02 \text{ in}}{2} \\ &= 1.01 \text{ inches} \end{aligned}$$

d. determine Q_{P4}

$$\begin{aligned} Q_{P4} &= (3870 \text{ cfs}) \left(1 - \frac{1.01}{19}\right) \\ &= 3664 \text{ cfs} \end{aligned}$$

6. STEP 5: Determine surcharge height for Q_{P4} and $STOR_4$

a. from Figure 1 surcharge height for $Q_{P4} = 3664 \text{ cfs}$

$$\begin{aligned} \text{Surcharge elev} &= 26.55 \text{ feet} \\ \text{Spillway-stopping elev} &= \frac{22.95}{3.60} \text{ feet} \end{aligned}$$

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CLIENT <u>Army Corps</u>	JOB NO. <u>274-7901</u>	PAGE <u>12 of 22</u>
PROJECT <u>Flood Water Works Dam</u>	COMPTD. BY <u>BWP</u>	DATE <u>12/19/79</u>
DETAIL <u>to bridge sales</u>	CK'D. BY <u>KMS</u>	DATE <u>12/19/79</u>

b. determine $STOR_4$

$$STOR_4 = \frac{(18 + 35.5 \text{ acres}) (3.60 \text{ in.}) (1.2 \text{ in.})}{(1.8 \text{ sq. mi}) (640 \text{ acres/sq. mi.})}$$

$$= 1.00 \text{ inches}$$

c. determine $STOR_{AVG}$

$$STOR_{AVG} = \frac{1.00 \text{ in.} + 1.01 \text{ in.}}{2}$$

$$= 1.005 \text{ inches}$$

d. determine Q_{p5}

$$Q_{p5} = (3870 \text{ cfs}) \left(1 - \frac{1.005}{1.9}\right)$$

$$= 3665 \text{ cfs}$$

$STOR_5$ will also = 1.00 and with this process $STOR_{\#}$ and $STOR_{AVG}$ converging very slowly, however Q has changed only slightly. Therefore, will accept $Q = 3665 \text{ cfs}$

6 In Conclusion

a. Test flood discharge = 3665 cfs and will overtop dam crest by 1.9 feet

b. Spillway Capacity - slope log. & plane

(1) at elev 23.67 $Q = 100 \text{ cfs}$
(point at entrance to spillway)

(2) at elev 24.65 $Q = 375 \text{ cfs}$
(dam crest)

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CLIENT Home Corp JOB NO. 274-7301 PAGE 2 of 22
PROJECT Flood Water Storage Dam COMPTD. BY PWP DATE 2/2/70
DETAIL Hydrology - Tables CK'D. BY WBS DATE 2/2/70

(3) at elev 26.55 feet $Q = 1190 \text{ cfs}$
(test flood)

c Spillway Capacity - stoplogs removed

(1) at elev 23.67 $Q = 795 \text{ cfs}$

2 at elev 24.65 $Q = 1275 \text{ cfs}$

(3) at elev. 26.55 feet $Q = 2475 \text{ cfs}$

d Spillway Capacity - stoplogs removed - service gates
open

(1) at elev 23.67 $Q = 835 \text{ cfs}$

(2) at elev 24.65 $Q = 1390 \text{ cfs}$

(3) at elev 26.55 $Q = 2595 \text{ cfs}$

CLIENT <u>Long CREEK</u>	JOB NO. <u>274-7901</u>	PAGE <u>14 of 22</u>
PROJECT <u>East Water Works Dam</u>	COMPTD. BY <u>BWP</u>	DATE <u>12/2/79</u>
DETAIL <u>More Hydrologic Calcs</u>	CK'D. BY <u>KHS</u>	DATE <u>12/2/79</u>

III Using "Rule of Thumb" Guidance for Estimating Downstream Dam Failure Hydrographs Examine Impact of dam failure

1. Pertinent Data

a. Failure occurs when reservoir level at crest of
dam elev = 24.65 ft.

b. Storage at crest elevation estimated to be
approximately 122 acre-ft.

A. REACH 1

1. STEP 1: Determine reservoir storage at time of
failure
from previous calcs = 117 acre-ft

2. STEP 2: Determine Peak Failure Outflow (Q_{P1})

$$Q_{P1} = 8/27 W_b \sqrt{g} Y_0^{3/2}$$

where: W_b = Breach width (use 40% of
total length)

$$= (0.40)(248 \text{ feet})$$

$$\approx 99 \text{ feet}$$

Y_0 = Total height from river bed
to pool level at failure

$$\text{pool level} = 24.65 \text{ ft}$$

$$\text{elev end of conveyance} = \frac{2.6}{15.05}$$

$$Y_0 \approx 15 \text{ feet}$$

$$Q_{P1} = (8/27)(99 \text{ feet})(32.2 \text{ ft/s}^2)^{1/2}(15 \text{ ft})^{3/2}$$

$$\approx 9,670 \text{ cfs}$$

CLIENT Army Corps JOB No. 274-7901 PAGE 50-22
PROJECT Exeter Water Works Dam COMPTD. BY BWP DATE 12/21/70
DETAIL More Hydrologic Calcs CK'D. BY 1/1/71 DATE 1/1/71

3. STEP 3: Prepare Stage-discharge curve - in Reach
1. Since reach is controlled by culverts beneath Portsmouth Avenue, the stage-discharge curve will represent culvert discharge (normal discharge and then choked flow) to elevation 18.7 feet. At this point, flow over the road will occur. The stage-discharge data have been summarized in Figure 3

1 Data:

- 1 Length of reach ≈ 400 ft
- 2 Culverts -

SIZE	Slope	Length
6' ϕ CMP	0.009	≈ 100 ft
4' ϕ CMP	0.011	≈ 100 ft

4. STEP 4: Estimate Reach Outflow

a Determine Stage for $Q_{p1} = 14,500$ cfs from Figure 3 and volume in reach

(1) Stage = 22.4 feet (Depth = $22.4' - 3.6' = 18.8'$)

(2) Volume in reach

using trapezoidal shaped channel cross section



$$X\text{-Area} = 0.5 (18.8' + 3.6') \times 18.8' \\ \approx 4465 \text{ ft}^2$$

$$\text{Volume} = (400 \text{ ft}) (4465 \text{ ft}^2) \left(\frac{1 \text{ acre}}{43,560 \text{ ft}^2} \right)$$

$$\approx 41.0 \text{ acre-ft}$$

Since $V < \frac{S}{2}$ reach length OK

b. Determine Q_{p2} (Trib.)

CLIENT W. W. W. Co. JOB NO. 224-790 PAGE 6 of 22
PROJECT Water Order No. 100 COMPTD. BY W. W. W. DATE 2/12/74
DETAIL Hydrologic Calcs CK'D. BY W. W. W. DATE 2/12/74

$$\begin{aligned} Q_{P2}(\text{TRIAL}) &= Q_{P1} \left(1 - \frac{V}{S}\right) \\ &= (9,670 \text{ cfs}) \left(1 - \frac{41 \text{ ac-ft}}{117 \text{ ac-ft}}\right) \end{aligned}$$

$$Q_{P2}(\text{TRIAL}) \approx 6,280 \text{ cfs}$$

c. Compute V_2 using $Q_{P2}(\text{TRIAL})$

From Figure 3 determine stage for $Q_{P2}(\text{TRIAL})$

$$\begin{aligned} \text{Stage} &\approx 21.8 \text{ f.} \quad (\text{Depth} = 21.8 - 3.6 = 18.2 \text{ f.}) \\ X\text{-Area} &\approx (2.5)(13.2)(330 + 15) \approx 3,595 \text{ ft}^2 \end{aligned}$$

$$\begin{aligned} V_2 &= (\text{reach length})(X\text{-Area}) \\ &= (400 \text{ ft})(3,595 \text{ ft}^2) \left(\frac{1 \text{ acre}}{43,560 \text{ ft}^2}\right) \\ &\approx 33 \text{ acre-ft} \end{aligned}$$

d. Average V_1 and V_2 and compute Q_{P2}

$$\begin{aligned} (1) V_{\text{avg}} &= \frac{V_1 + V_2}{2} \\ &= \frac{41.0 \text{ ac-ft} + 33.0 \text{ ac-ft}}{2} \end{aligned}$$

$$V_{\text{avg}} = 37.0 \text{ acre-ft}$$

$$\begin{aligned} (2) Q_{P2} &= Q_{P1} \left(1 - \frac{V_{\text{avg}}}{S}\right) \\ &= (9,670 \text{ cfs}) \left(1 - \frac{37 \text{ ac-ft}}{117 \text{ ac-ft}}\right) \end{aligned}$$

$$Q_{P2} \approx 6,610 \text{ cfs}$$

CLIENT Army Corps
PROJECT Foster Water Works Dam
DETAIL Hydrologic Calc

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COMPTD. BY RUP DATE 12/17/20
CK'D. BY ... DATE ...

B. REACH 2

1. STEP 3 Prepare stage-discharge curve for Reach 2

a. Pertinent Data

- (1) Reach length ≈ 300
- (2) Slope ≈ 0.001
- (3) Manning's "n" = 0.06
- (4) Channel shape - trapezoidal
- (5) base width $\approx 15'$

b. See Figure 3 for curve

2. STEP 4

a. Determine stage for $Q_{P2} = 6,610 \text{ cfs}$ from Figure 3 and volume in reach

(1) stage = 16.6 feet (depth = $16.6' - 2.8' = 13.8'$)

(2) Volume in reach

$$V_1 = \frac{(300 \text{ ft}) \left[(0.5)(13.8 \text{ ft})(300 \text{ ft} + 15 \text{ ft}) \right]}{43,560 \text{ sq ft/acre}}$$
$$= 15.0 \text{ acre-ft}$$

$$V < \frac{S}{2} \text{ reach length OK}$$

b. Determine $Q_{P3} \text{ (TRIAL)}$

$$Q_{P3(\text{TRIAL})} = Q_{P2} \left(1 - \frac{V_1}{S} \right)$$
$$= (6610 \text{ cfs}) \left(1 - \frac{15.0}{117} \right)$$

$$Q_{P3(\text{TRIAL})} = 5,760 \text{ cfs}$$

CLIENT <u>FCM Corp</u>	JOB NO. <u>274-390</u>	PAGE <u>30-22</u>
PROJECT <u>For the Water Works Dam</u>	COMPTD. BY <u>EDP</u>	DATE <u>10/22/70</u>
DETAIL <u>Hydrologic Calc.</u>	CK'D. BY <u>PLS</u>	DATE <u>10/27/70</u>

c compute V_2 using Q_{P3} (to be)

From Figure 3 determine stage for Q_{P3} ...

$$\text{Stage} \approx 15.3 \text{ feet} \quad (\text{Depth} = 15.9' + 2.8' = 18.7')$$

$$\begin{aligned} X\text{-Area} &\approx (0.5)(13.0 \text{ ft})(285 \text{ ft} + 15 \text{ ft}) \\ &\approx 1950 \text{ ft}^2 \end{aligned}$$

$$V_2 = \frac{(300 \text{ ft})(1950 \text{ ft}^2)}{43,560 \text{ ft}^2/\text{acre}}$$

$$= 13.4 \text{ acre-ft}$$

d. Average V_1 and V_2 and compute Q_{P3}

$$\begin{aligned} (1) V_{\text{avg}} &= \frac{15.0 \text{ ac-ft} + 13.4 \text{ ac-ft}}{2} \\ &= 13.4 \text{ ac-ft} \end{aligned}$$

$$\begin{aligned} (2) Q_{P3} &= Q_{P2} \left(1 - \frac{V_{\text{avg}}}{3}\right) \\ &= (6,610 \text{ cfs}) \left(1 - \frac{13.4}{117}\right) \\ &\approx 5,810 \text{ cfs} \end{aligned}$$

C REACH 3

1. STEP 3 Prepare stage-discharge curve for Reach

a Pertinent Data

- (1) Reach length = 450 feet
- (2) Slope ≈ 0.0002
- (3) Manning's "n" = 0.09
- (4) Channel shape - trapezoidal
- (5) base width $\approx 430'$

b see Figure 3 for curve

CLIENT Prime Corp JOB NO. 274-2901 PAGE 2 of 2
PROJECT Former Water Works Dam COMPTD. BY BUP DATE 11-22-71
DETAIL Hydrologic Calcs CK'D. BY ... DATE ...

2. STEP 4

a. Determine stage for $Q_{P3} = 5810 \text{ cfs}$ from Figure 1 and volume in reach

(1) Stage ≈ 9.8 feet (Depth = $9.8' - 2.7' = 7.1'$)

(2) Volume in reach

$$V_1 = \frac{(450 \text{ ft}) \left[(0.5) (7.1' (3000 - 5300)) \right]}{43,560 \text{ ft}^2/\text{acre}}$$

$$= 31.9 \text{ acre-ft}$$

$V_1 < \frac{1}{2} \text{ reach length}$

b. Determine Q_{P4} (TRIAL)

$$Q_{P4(\text{TRIAL})} = Q_{P3} \left(1 - \frac{V_1}{S} \right)$$

$$= 5810 \text{ cfs} \left(1 - \frac{31.9}{117} \right)$$

$$Q_{P4(\text{TRIAL})} \approx 4,230 \text{ cfs}$$

c. Compute V_2 using $Q_{P4(\text{TRIAL})}$

From Figure 3 determine stage for $Q_{P4(\text{TRIAL})}$

$$\text{Stage} \approx 8.8 \text{ feet (Depth} = 8.8' - 2.7' = 6.1')$$

$$X\text{-Area} = (0.5) (6.1' (3400 - 5500))$$

$$\approx 2608 \text{ ft}^2$$

$$V_2 = \frac{450 \text{ ft} \cdot 2608 \text{ ft}^2}{43,560 \text{ ft}^2/\text{acre}}$$

$$\approx 26.9 \text{ acre-ft}$$

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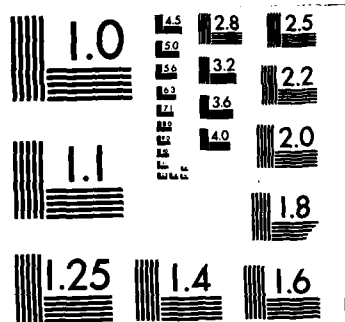
NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAM
EXETER WATER WORKS DAM. (U) CORPS OF ENGINEERS WALTHAM
MA NEW ENGLAND DIV MAR 80

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END



MICROCOPY RESOLUTION TEST CHART
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CLIENT Army Corps

JOB NO. 274-7901

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PROJECT Exeter Water Works Dam

COMPTD. BY BWP

DATE 12/22/79

DETAIL Hydrologic Calcs

CK'D. BY AMS

DATE 1/20/80

d. Average V_1 and V_2 and compute Q_{P4}

$$(1) V_{avg} = \frac{31.9 \text{ acre-ft} + 26.9 \text{ acre-ft}}{2}$$

$$= 29.4 \text{ acre-ft}$$

$$(2) Q_{P4} = Q_{P3} \left(1 - \frac{V_{avg}}{S} \right)$$

$$= (5,810 \text{ cfs}) \left(1 - \frac{29.4}{117} \right)$$

$$Q_{P4} \approx 4,350 \text{ cfs}$$

FIGURE 3
DISCHARGE vs. ELEVATION

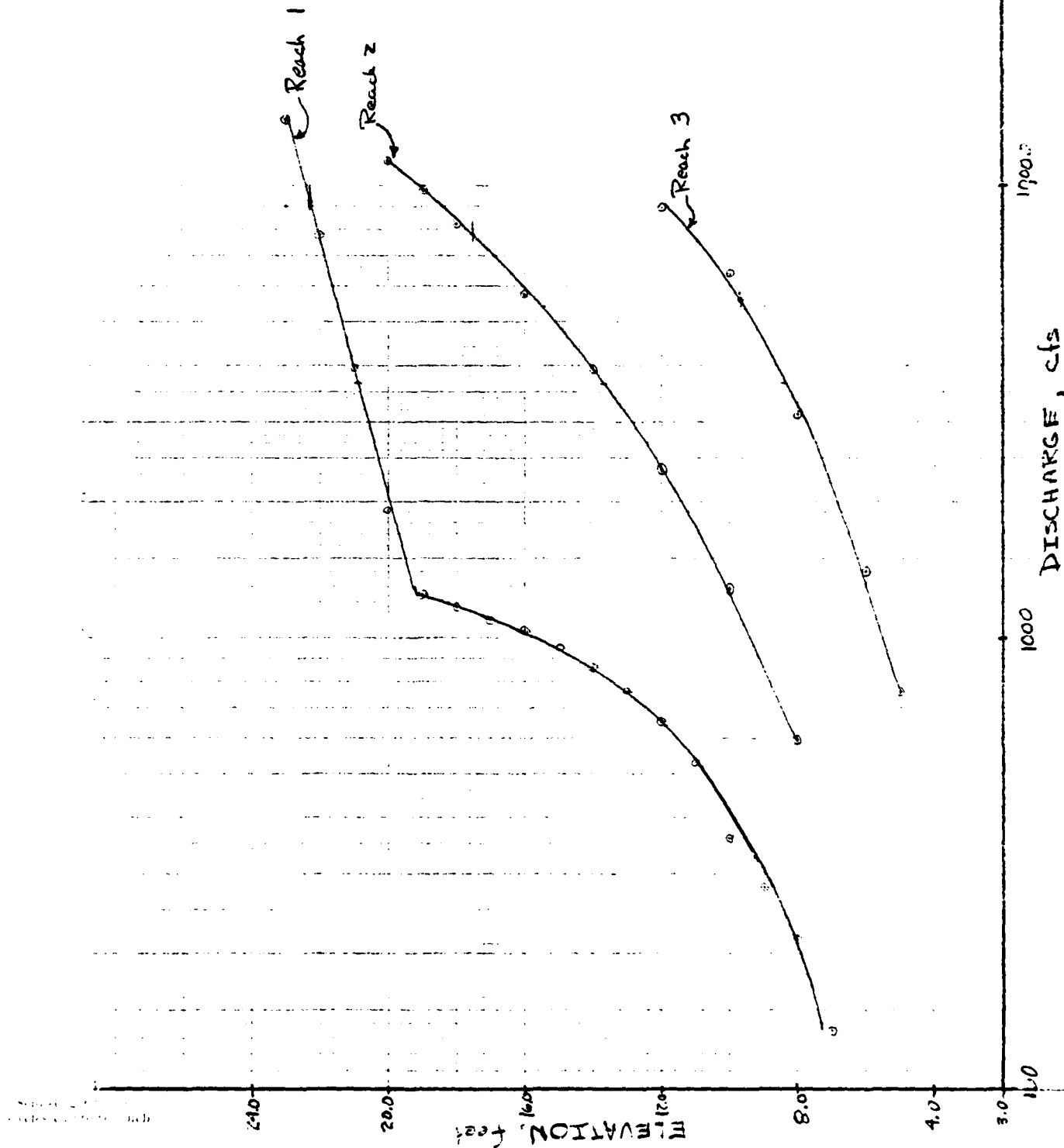
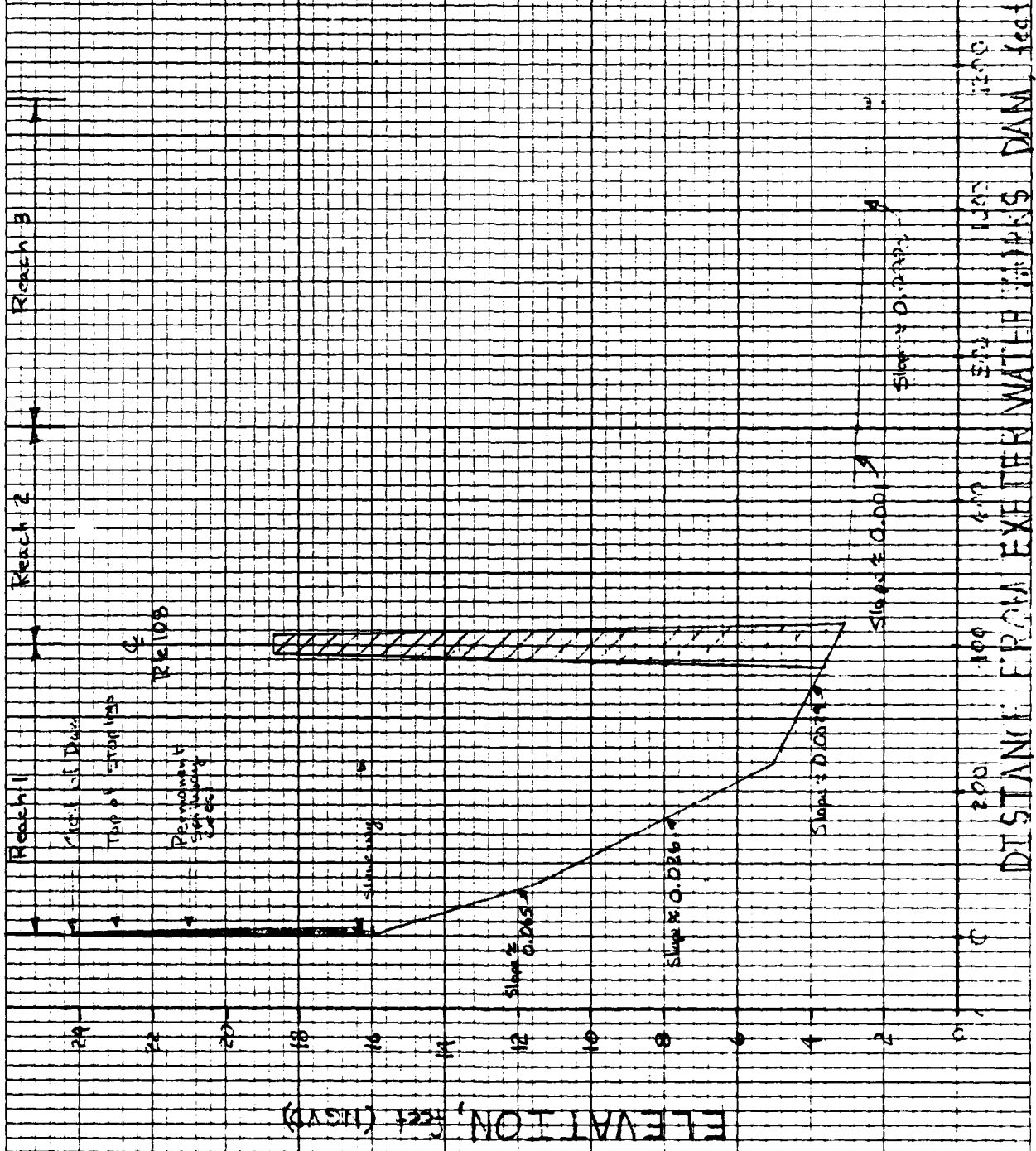


FIGURE 4
STREAM CHANNEL PROFILE



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