LOWER CONNECTICUT RIVER BASIN
MIDDLETOWN, CONNECTICUT

CRYSTAL LAKE DAM
CT 00138

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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

JANUARY 1980

DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

REFERENCE OR OFFICE SYMBOL	SUBJECT
NEDED-E e)	Dam Safety Draft Report Flaherty-Giorora

TO	FROM	DATE	CMT
Chief, Design Branch Chief, F&M Branch Chief, Water Control Br.	Chairman, Dam Safety Review Board	11 Jan 80	

Attached for your review are two copies of the Architect-Engineer's draft report fo CRYSTAL LAKE Dam, Identity No. CT 00138 The review board meeting date for this report is 25 Jan 80. Please present your comments in writing under the format shown below. Please return one copy with your comments. Cost code for this rewiew is ABA0/070/000000 (FY80)

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NATIONAL PROGRAM OF INSPECTION OF NON-FEDERAL DAMS
DRAFT REPORT REVIEW COMMENTS
CRYSTAL LAKE DAM, IDENTITY NO. CT 00138
F & M BRANCH

Page No.	Comments
15	(1) Par 7.1 c: Change to "two" years.
	(2) Par 7.2: Delete a and b
	(3) Par 7.3 a(2): Change to "two" years

These comments also apply to Brief Assessment.

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NOTE: Bring nine (9) copies of comments to review board meeting.

DA FORM 1 FEB 62 2496 REPLACES DD FORM 96, WHICH IS OBSOLETE. GPO-1975-665-422/106

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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18. SUPPLEMENTARY NOTES

Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

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

DAMS, INSPECTION, DAM SAFETY,

Lower Conn. River Basin
Middletown, Conn.
Crystal Lake Dam

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

Crystal Lake is an earthen embankment dam with a maximum ehight of 50 ft. and a length of 130 ft. The upstream and downstream slopes are faced with riprap.The dam is judged to be in generally fair condition. The vertical and horizontal alignment of the dam is good. Some minor erosion along the dam adjacent to the left abutment was noted.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

CRYSTAL LAKE DAM

CT 00138

LOWER CONNECTICUT RIVER BASIN

MIDDLETOWN, CONNECTICUT

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT

Identification No.:	CT 00138
Name of Dam:	Crystal Lake Dam
Town:	Middletown
County and State:	Middlesex, Connecticut
Stream:	Tributary - Sumner Brook
Date of Inspection:	1 November, 1979

BRIEF ASSESSMENT

Crystal Lake is an earthen embankment dam with a maximum height of 50 feet and a length of 130 feet. The upstream and downstream slopes are faced with riprap. The dam has a water control structure with a 36-inch diameter outlet pipe controlled by two sluice gates and a stop log spillway.

The dam impounds Crystal Lake which is used for recreational purposes. The lake has a storage volume of 350 acre-feet. Based upon the height of the dam, the size classification is intermediate. A breach of the dam could affect about 20 homes in the probable impact area. State Highway Route 155 would also be flooded. With the possibility of some loss of life and the probability of excessive economic losses, the dam has been classified as having a high hazard potential.

The dam is judged to be in generally fair condition. The crest is level, and no lateral movement was observed. The vertical and horizontal alignment of the dam is good. Some minor erosion along the dam adjacent to the left abutment was noted. The riprap paving on the upstream face is in good condition. The rockfill downstream face is also in good condition. Small trees and scrub brush are growing on the upstream and downstream slopes and could cause problems if not removed.

The total capacity of the water control structure and the 36-inch diameter outlet pipe is adequate to pass the spillway test flood with a freeboard of 0.8 feet.

Within one year of receipt of the Phase I Inspection Report, the owner, the State of Connecticut, should study and evaluate the following: 1) develop methods to monitor and ensure proper operation of the pressure relief wells; and 2) develop methods of determining potential for seepage through the dam.

The owner should also carry out the following operations and maintenance procedures: 1) maintain clear of trees and brush the dam embankment, an area within 25 feet of the downstream

toe, and the outlet channel for a distance of 100 feet downstream of the dam; 2) engage a qualified registered engineer to make a comprehensive technical inspection once every year; 3) establish a surveillance program for use during and immediately after heavy rainfall and also a warning program to follow in case of emergency conditions and 4) remove grate or establish provisions for quick release at downstream end of 36 in. diameter outlet pipe.

S Giavara

S. Giavara, P.E.
President

Registered CT. 7634

g. Purpose of Dam. The dam impounds Crystal Lake which is used for recreational purposes. The previous dam and reservoir was used for water storage purposes by the Russell Manufacturing Company.

h. Design and Construction History. The existing dam was designed in 1963 and constructed in 1966. A Construction Permit was issued on March 24, 1964 and a Certificate of Approval was issued on April 27, 1966 for the construction of this dam by the State Water Resources Commission. Construction plans and specifications were prepared by Onderdonk and Lathrop, Consulting Engineers, Glastonbury, Connecticut. Pertinent construction plan sheets are contained in Appendix B. Results of borings and hydraulic/hydrologic design information is also included on these plans.

The original dam at this site failed on April 27, 1961. The cause of failure was thought to be due to excessive seepage. The flood wave resulted in three persons being slightly injured and eleven homes were damaged (see Appendix B for Hartford Times account).

i. Normal Operation Procedures. Water levels in the lake are normally maintained at the spillway crest elevation of 175.0 feet. During the fall months, the water surface level is drawn down by opening the sluice gates to aid in the control of aquatic vegetation.

1.3 PERTINENT DATA:

a. Drainage Area. The drainage area of Crystal Lake is 0.26 square miles which consist of moderately sloping hillsides surrounding the lake. The land use is limited to the scattered residential dwellings which are located around the perimeter of the lake. The watershed is about 4,500 feet in length and has a maximum width of about 2,000 feet.

b. Discharge at Dam Site.

1) The outlet works utilize the 36-inch diameter concrete sluiceway conduit which passes through the dam. This conduit transmits all spillway and outlet works flow. The outlet works consist of two 24 inch x 24 inch sluicegates at the bottom of the water control structure. These gates are manually operated by two valve stems located on top of this structure. The 36-inch diameter concrete sluiceway conduit has an inlet invert elevation of 147.0 feet and an outlet invert elevation of 130.0 feet. The discharge capacity of the outlet works (gates opened) under 28 feet of head (elevation 175.0 feet) is 180 cfs.

2) There are no known records of past floods or flood stage heights at the dam.

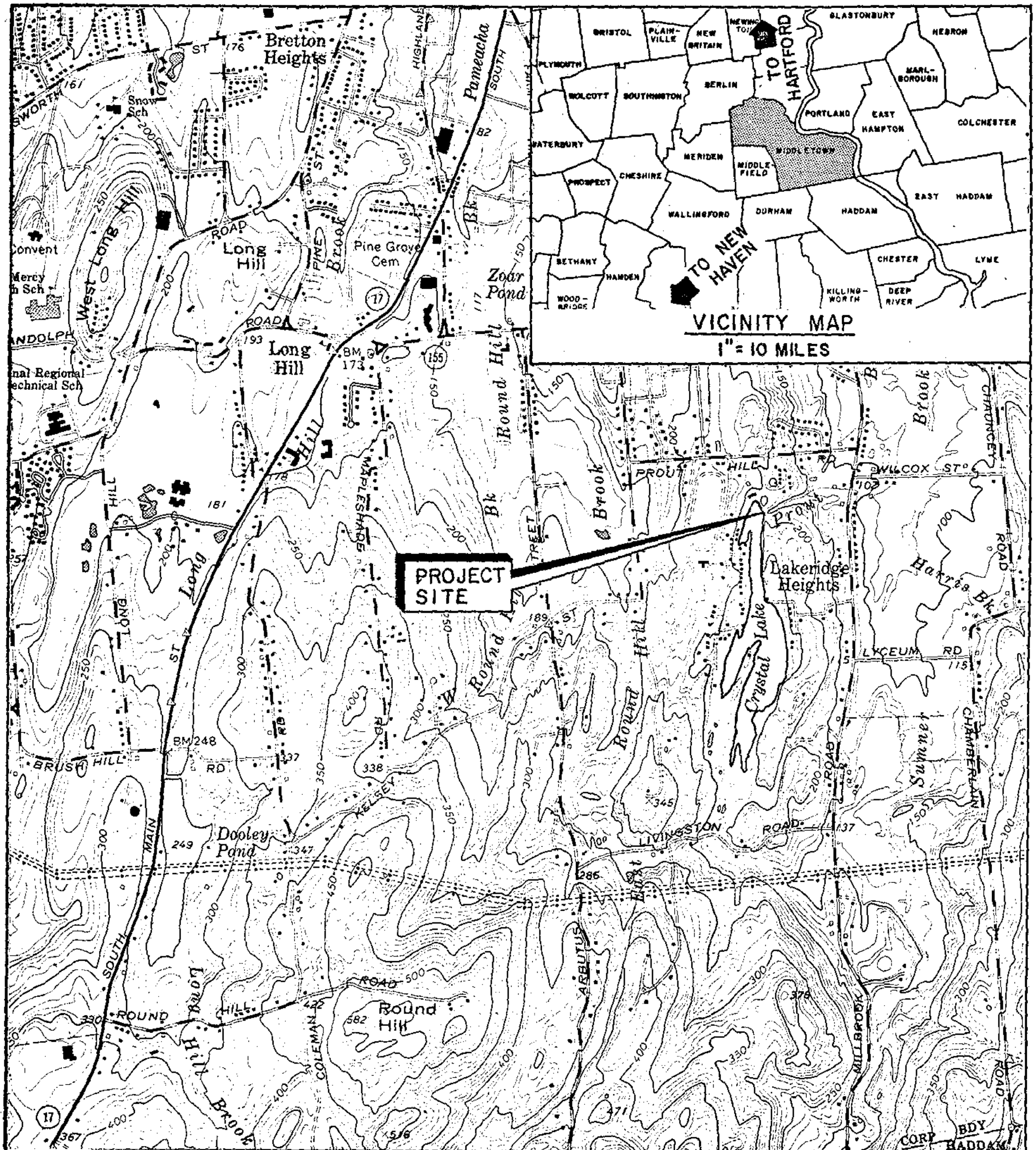
3) The ungated spillway capacity at the top of dam - 196 cfs @ El. 180.5.

4) The ungated spillway capacity at test flood elevation - 184 cfs @ EL. 179.7.

TABLE OF CONTENTS

APPENDIXES

Overview Photo: Crystal Lake Dam



SCALE IN FEET

2000 1000 0 2000

CRYSTAL LAKE DAM

LOCATION MAP

MIDDLETOWN , CONNECTICUT

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
CRYSTAL LAKE DAM - CT 00030

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 through 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. Flaherty Giavara Associates, P.C. has been retained by the New England Division to inspect and report on selected dams in the State of Connecticut. Authorization and notice to proceed was issued to Flaherty Giavara Associates, P.C. under a letter of 19 October 1979 from William E. Hodgson, Jr., Colonel, Corps of Engineers. Contract No. DACW33-80-C-0001 has been assigned by the Corps of Engineers for this work.

b. Purpose.

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

2) Encourage and assist 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 THE PROJECT:

a. Location. The Crystal Lake Dam is located in Middletown, Connecticut on a tributary stream to Sumner Brook. The lake is located approximately 2 miles south of the center of Middletown. The reservoir is shown on the U.S.G.S. Topographic Map "Middletown, Conn." at a latitude of 41° 31' 19" and at a longitude of 72° 38' 19". The Location Map on page vi shows the location of the dam.

b. Description of Dam and Appurtenances. The Crystal Lake Dam is an earthen embankment dam with a maximum height of 50 feet and a length of 130 feet. The dam embankment elevation is 180.5 feet and the normal lake elevation is 175.0 feet. The upstream and downstream slopes are faced with riprap. The downstream embankment slope is 2 horizontal to 1 vertical. The upstream embankment slope varies from

4:1 for the first 50 feet, and then slopes at 3:1. The construction plans indicate that the center of the dam contains an impervious fill core and a grout cap cut off wall. In addition, the plans indicate a stone drainage blanket and a pressure relief well.

The appurtenant structures consist of a water control structure and a sluiceway through the dam. The water control structure functions as a wet intake tower. The water control structure receives water from a submerged concrete intake structure located at the reservoir floor 100 feet from the face of the dam. Water is transmitted from the intake structure to the water control structure via a 36-inch diameter concrete pipe with an inlet invert elevation of 150.0 feet. The first two chambers of the water control structure contain water to an elevation of 175.0 feet with the outlet gates in the closed position. Water enters the third chamber (dry during normal operation) over a stop log spillway with a crest elevation of 175.0 feet. Water is transmitted from the third chamber through the dam via a 36-inch concrete sluiceway conduit with an inlet invert elevation of 147.0 feet and an outlet invert elevation of 130.0 feet. The outlet pipe ends at the toe of the dam at a concrete endwall with wingwalls.

The outlet works consist of two 24 inch x 24 inch sluice gates at the base of the water control structure. These gates are manually operated by metal stems which extend above the top of this structure.

c. Size Classification. Crystal Lake has a storage volume of 350 acre-feet and a dam height of 50 feet above streambed. A height greater than 40 feet classifies this structure in the "intermediate" category according to guidelines established by the Corps of Engineers.

d. Hazard Classification. The dam is classified as having a "high" hazard potential. Approximately 20 dwellings are located in the dam failure impact area. In addition, the center of the City of Middletown is located approximately 2 miles downstream. There is significant commercial and industrial development which would be inundated by a flood resulting from dam failure resulting in excessive economic loss.

e. Ownership. This dam is presently owned by the Connecticut Department of Environmental Protection, Division of Conservation and Preservation, 165 Capitol Avenue, Hartford, Connecticut; Dennis P. DeCarli, Deputy Commissioner; Phone: 566-4522. The previous dam at this site was owned by Russell Manufacturing Company, Middletown, Connecticut.

f. Operator. The dam is operated by the Connecticut Department of Environmental Protection, Division of Conservation and Preservation, Region III Headquarters, East Hampton, Connecticut; John Spencer, Region Manager; phone: 295-9523.

g. Purpose of Dam. The dam impounds Crystal Lake which is used for recreational purposes. The previous dam and reservoir was used for water storage purposes by the Russell Manufacturing Company.

h. Design and Construction History. The existing dam was designed in 1963 and constructed in 1966. A Construction Permit was issued on March 24, 1964 and a Certificate of Approval was issued on April 27, 1966 for the construction of this dam by the State Water Resources Commission. Construction plans and specifications were prepared by Onderdonk and Lathrop, Consulting Engineers, Glastonbury, Connecticut. Pertinent construction plan sheets are contained in Appendix B. Results of borings and hydraulic/hydrologic design information is also included on these plans.

The original dam at this site failed on April 27, 1961. The cause of failure was thought to be due to excessive seepage. The flood wave resulted in three persons being slightly injured and eleven homes were damaged (see Appendix B for Hartford Times account).

i. Normal Operation Procedures. Water levels in the lake are normally maintained at the spillway crest elevation of 175.0 feet. During the fall months, the water surface level is drawn down by opening the sluice gates to aid in the control of aquatic vegetation.

1.3 PERTINENT DATA:

a. Drainage Area. The drainage area of Crystal Lake is 0.26 square miles which consist of moderately sloping hillsides surrounding the lake. The land use is limited to the scattered residential dwellings which are located around the perimeter of the lake. The watershed is about 4,500 feet in length and has a maximum width of about 2,000 feet.

b. Discharge at Dam Site.

1) The outlet works utilize the 36-inch diameter concrete sluiceway conduit which passes through the dam. This conduit transmits all spillway and outlet works flow. The outlet works consist of two 24 inch x 24 inch sluicegates at the bottom of the water control structure. These gates are manually operated by two valve stems located on top of this structure. The 36-inch diameter concrete sluiceway conduit has an inlet invert elevation of 147.0 feet and an outlet invert elevation of 130.0 feet. The discharge capacity of the outlet works (gates opened) under 28 feet of head (elevation 175.0 feet) is 180 cfs.

2) There are no known records of past floods or flood stage heights at the dam.

3) The ungated spillway capacity at the top of dam - 196 cfs @ El. 180.5.

4) The ungated spillway capacity at test flood elevation - 184 cfs @ EL. 179.7.

5) The gated spillway capacity at normal pool elevation is not applicable at this dam.

6) The gated spillway capacity at test flood elevation is not applicable at this dam.

7) The total spillway capacity at test flood elevation - 184 cfs @ El. 179.7.

8) The total project discharge at the top of dam elevation is not applicable at this dam.

9) The total project discharge at test flood elevation - 184 cfs @ El. 179.7

c. Elevation (ft. above MSL).

1) Streambed at toe of dam 130.0

2) Bottom of cutoff .... 128±

3) Maximum tailwater .... N/A

4) Recreation pool 175.0

5) Full flood control pool .... N/A

6) Spillway crest 175.0

7) Design surcharge (Original Design) 177.0

8) Top of dam 180.5

9) Test flood design surcharge 179.7

d. Reservoir (Length in feet).

1) Normal pool 3,700

2) Flood control pool .... N/A

3) Spillway crest pool 3,700

4) Top of dam 3,720

5) Test flood pool 3,715

e. Storage (acre-feet).

1) Normal pool 154

2) Flood control pool .... N/A

3) Spillway crest pool 154

4) Top of dam 350

5) Test flood pool 322

f. <u>Reservoir Surface</u> (acres).

1) Normal pool 30.8

2) Flood control pool .... N/A

3) Spillway crest 30.8

4) Test flood pool 38.5

5) Top of dam 39.7

g. <u>Dam</u>.

1) Type .... Earth embankment

2) Length .... 130 feet

3) Height .... 50 feet

4) Top Width 20

5) Side Slopes ..... Downstream: 2 horizontal to 1 vertical
Upstream: Varies 4 to 3 horizontal to 1 vertical

6) Zoning .... Impervious fill core with pervious fill embankment

7) Impervious Core .... Yes

8) Cutoff .... Grout cap cutoff wall to elevation 128±

9) Grout curtain .... Grout surface seal

h. <u>Diversion and Regulating Tunnel</u>.

1) Type .... Not applicable

2) Length .... Not applicable

3) Closure .... Not applicable

4) Access .... Not applicable

5) Regulating Facilities .... Not applicable

i. <u>Spillway</u>.

1) Type .... Stop log spillway contained within water control structure

2) Length of weir .... 6.0 feet

3) Crest elevation 175.0

4) Gates .... No

5) U/S Channel .... Reservoir

6) D/S Channel .... Natural stream channel with gravel and cobbles

j. <u>Regulating Outlets</u>.

1) Invert .... 147.0 feet

2) Size .... 36" circular conduit

3) Description .... Reinforced concrete pipe

4) Control mechanism .... Hand-operated valve stems

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

The principal engineering data available are:

a. Plans - Construction of Dam, Crystal Lake, Sheets 1-8, 16 September, 1962. Plans prepared by Onderdonk and Lathrop, Glastonbury, CT (see Appendix B).

b. Specifications for Construction of Dam, Crystal Lake, Middletown, Connecticut, Agriculture and Natural Resources, Board of Fisheries and Game, Project BI-BB-53, August, 1962.

c. Several items of correspondence pertaining to the project (see Appendix B).

2.2 CONSTRUCTION:

No information is available concerning the foundation preparation or embankment construction. Details shown on the contract drawings are in good agreement with field observations.

2.3 OPERATION DATA:

Operation of the dam by the State DEP, Region III, is on an informal basis to satisfy the recreational interests of lake users.

2.4 EVALUATION:

a. Availability. The information available concerning the embankment consists of a design cross section and the identification of the embankment materials as "impervious core fill" and "pervious fill." No engineering data is available concerning the properties of the embankment materials. No information is available about the foundation materials encountered during the construction of the embankment.

b. Adequacy. The available data are not sufficient to evaluate the soils in the core and shells and in the foundation of the dam. The evaluation must be based primarily on the results of the visual inspection which is adequate for the purposes of the Phase I investigation.

c. Validity. No conflicts have been noted between the available data and the observations made during the inspection. In general, there is no reason to question the validity of the available data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

a. General. Based on visual inspection, history and general appearance, Crystal Lake Dam and its appurtenances are judged to be in fair condition. The crest is level, and no lateral movement was observed. The vertical and horizontal alignment of the dam is good. Some minor erosion along the dam adjacent to the left abutment was noted. The riprap paving on the upstream face is in good condition. The rockfill downstream face is also in good condition. Small trees and scrub brush is growing on the upstream and downstream slopes and could cause problems if not removed. The gate mechanism on the outlet structure was not operated during the inspection.

b. Dam. Crystal Lake Dam is an earth embankment about 50 feet high, 130 feet long and 20 feet wide at the crest.

1) Upstream Slope - Most of the upstream side of the dam is covered by large flat riprap blocks. Brush and grass are growing between the riprap blocks as shown in Photos No. 1 and No. 2. A small concrete cutoff wall, 1-ft.-wide by 2-ft.-deep, is located on the crest of the upstream slope as indicated in Photo No. 3.

2) Crest - The crest of the dam is covered with grass over most of its length. The grass has not been mowed recently, but there is a footpath which is bare of vegetation near the downstream edge of the crest. The contact between the earthen embankment and the right abutment is not clearly defined (Photos No. 3 and No. 4). Three 2½-inch diameter pipe casings extend about 2 feet above the crest of the dam, the purpose of these pipes are unknown.

3) Downstream Slope - The downstream side of the dam consists of rockfill overlying the embankment section (Photos No. 5 and No. 6). The rockfill extends to the downstream toe of the dam and is covered by extensive small trees and fallen logs as indicated in Photo No. 7. A portion of the contact with the left abutment has been covered with trash and debris as shown in Photo No. 9. Bedrock is exposed at the contact with the right and left abutments.

c. Appurtenant Structures. The visible portions of the concrete water control structure above the water level surface is in good condition. The top of the structure is enclosed with a perimeter chain link fence. There are aluminum grate covers over each of the three interior chambers. Two valve stems without operator handles were observed on the top of this structure (see Photo No. 10).

The inlet which transmits water to the water control structure is located offshore from the dam at the bottom of the reservoir and was therefore not visible for inspection.

The water control structure functions as the spillway and the outlet works. At the time of the visual inspection, the outlet gates at the base of this structure were closed and water was discharging over the stoplog spillway within the structure.

All water which passes through the water control structure is conveyed through the dam in a 36-inch diameter concrete conduit. This conduit extends from the water control structure and outlets at the toe of the dam. The conduit was visually inspected at its outlet located at the base of the downstream face of the dam embankment, and found to be in good condition. The 36" diameter pipe outlets at a concrete endwall with concrete wingwalls. All concrete was in good condition, with no evidence of spalling, erosion or efflorescence. A metal bar rack bolted to the endwall prevents access to the outlet conduit (see Photo No. 11).

d. <u>Reservoir Area</u>. The reservoir has well vegetated banks at slight to moderate slopes. In addition, there are scattered residential homes located along the perimeter of the lake (see Photo No. 13).

There was no evidence of slides or sloughing along the banks of the lake. No sediment deposits were observed above the water level of the lake. Sediment inputs to the lake would be a result from natural runoff and urbanization.

e. <u>Downstream Channel</u>. The outlet flows into a natural stream which begins at the base of the dam. The channel width varies from 5 to 10 feet with bed materials consisting of sand and gravel, with scattered cobbles and boulders. The bed appears stable but the banks experienced severe erosion when the original dam failed in 1961. These banks have since stabilized due to natural soil sloughing and revegetation. Approximately 100 feet downstream of the endwall outlet, there is a low valley without a well defined channel. The floodplain area and stream are heavily vegetated with brush and young saplings and is covered with forest litter and debris. The channel downstream of the outlet endwall is filled with fallen trees, brush, vegetation and trash as indicated in Photo No. 12.

3.2 EVALUATION:

Based on the visual inspection, Crystal Lake Dam is in fair condition.

The contract drawings indicate the existance of a relief well system beneath the downstream slope of the dam. The presence of this relief well system could not be confirmed during the site visit.

Trees growing on the downstream slope may blow over and pull out their roots causing a displacement of the rockfill. Brush and trees growing along the downstream toe make it difficult to inspect the dam and downstream toe area adequately.

The footpath which is bare of vegetation on the crest of the dam has low erosion resistance if the dam should be overtopped.

SECTION 4 - OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 OPERATIONAL PROCEDURES:

a. General. The water level in the pond can be controlled by two 24 inch x 24 inch sluice gates at the base of the water control structure. The pond level is maintained at El. 175.0 which is the top elevation of the stop planks in the water control structure. There appears to be no formal operating procedures.

b. Description of Any Warning System In Effect. There is no formal warning system in effect in the event of a failure or partial failure of the structure.

4.2 MAINTENANCE PROCEDURES:

a. General. It does not appear that any formal maintenance procedures are practiced at the dam. Numerous trees and brush have overgrown both the upstream and downstream slopes.

b. Operating Facilities. There are no formal maintenance procedures followed for the operating facilities.

4.3 EVALUATION:

Regular operation maintenance proceudres for this dam and its appurtenances have not been developed or implemented.

An emergency action plan should be prepared to prevent or minimize the impact of failure. This plan should list the expedient action to be taken and authorities to be contacted.

SECTION 5 - EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

5.1 GENERAL:

The Crystal Lake Dam is an earth embankment dam with a concrete water control structure which functions as a spillway and outlet works.

The water control structure receives water from a submerged concrete intake structure located at the bottom of the located reservoir about 100 feet from the upstream face of the dam. Water is transmitted from the intake structure to the water control structure via a 36 inch diameter concrete pipe.

The water control structure which is about 30 feet in depth contains three vertical rectangular chambers. Two 24 inch x 24 inch sluice gates are located at the bottom of this structure and comprise the outlet works. These gates are operated manually by metal stems which extend above the top of the structure. During normal lake operations, these sluice gates are closed. With the sluice gates closed, the first two chambers are filled with water to elevation 175. The wall between the second and third chamber consists of stop logs which function as a spillway for heads of up to 2 feet. For water levels in the reservoir greater than elevation 177, this opening discharges as orifice flow. In addition, when the water surface level rises above elevation 177.67, water enters through the grate over the third chamber, which operates as a drop inlet. Flow from the outlet structure is carried through the dam in a 36-inch concrete pipe that discharges at the base of the downstream slope.

The watershed area is 0.26 square miles which consists of the moderately sloping hillsides surrounding the lake. The watershed is wooded with scattered open areas. The land use is limited to the scattered residential developments which surround the lake. There are no upstream impoundments or other significant storage areas.

5.2 DESIGN DATA:

The existing dam was constructed during 1966. The only hydraulic/hydrology calculations available are contained on the construction plans. The data presented as follows:

Design Data

Drainage Area	200 acres
Lake Area	33 acres
Dam Elevation	180.5 ft.

Design Data

Spillway Elevation	175.0 ft.
Stop Log Control To Elevation	165.0 ft.
Maximum Drawdown Elevation	155.0 ft.
Design Storm Rainfall	4 in./hr.
Lake Storage (100% Runoff) at Elevation 177.0'	4 in. rainfall
Time of Concentration	54 min.
Design Runoff Coefficient	0.33
Spillway Width	6 ft.
Discharge at 2' Head	55 cfs
Discharge with Gates Opened at 25' Head	100 cfs

The design calculations show that for a 4-inch rainfall with 100 percent runoff , total storage would be provided at elevation 177 assuming no outflow. The discharge given for 2 feet of head over the spillway is 55 cfs. The discharge with the sluice gates opened for 25 feet of head is given as 100 cfs.

5.3 EXPERIENCE DATA:

No information is available on past flood experience or flood stages at the dam.

5.4 TEST FLOOD ANALYSIS:

Under established criteria (OCE guidelines), the recommended test flood for the size (intermediate) and hazard potential (high) classification is the probable maximum flood (PMF).

The PMF is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible for the area.

The magnitude of the PMF was developed using the Soils Conservation Service method for determining flow rates as described in "Design of Small Dams" by the Bureau of Reclamation (see Appendix D). Due to the small watershed area of the dam, three PMF's were developed based on probable maximum precipitations for storm durations of 1, 6 and 24 hours. Peak flows (PMF) for these three duration storms were calculated as 1595 cfs, 679 cfs, and 209 cfs respectfully. Triangular hydrographs were developed based on these PMF's, with the time durations set so that the hydrograph would contain the same volume of water as the estimated storm runoff.

For stage elevations from 175 to 177 feet discharges were computed as spillway flow with a weir coefficient of 3.3 (sharp crested weir). At water elevations greater than 177.67 discharges was computed by the summation of oriface flow over the spillway and the flow that enters the grate over the third chamber of the water control structure. At elevations greater than 179.4 the discharge capacity of the water control structure is limited by the capacity of the 36-inch diameter outlet. The maximum capacity of the water control structure at a stage of 5.5 feet corresponding to a top of dam elevation of 180.5, is 196 cfs. (The stage-discharge curve is contained in Appendix D.)

The three developed hydrographs were routed through the reservoir using a computer program based on stage-storage and stage-discharge data to determine the critical storm duration. The reservoir was assumed to be full to the spillway crest (elevation 175) prior to the storm event. The most critical storm for this dam is the 6-hour duration probable maximum precipitation. This storm results in a maximum water surface level of 179.7 feet, with 0.8 feet of remaining freeboard. Therefore, the capacity of the spillway is adequate to pass the PMF test flood outflow of 184 cfs without overtopping the dam (compare 196 cfs to 184 cfs).

5.5 DAM FAILURE ANALYSIS:

The downstream impact of a dam failure was analyzed using the COE "Rule of Thumb Guidance for Estimating Downstream Failure Hydrographs" dated April 1978.

Based upon an assumed breach width equal to 40% of the dam's width at mid-height, the peak flow leaving the dam would be 16,630 cfs, with an initial depth of 12.9 feet downstream of the dam. The flood wave routing analysis extended 9,800 feet downstream of the dam, to the approximate center of Middletown, Connecticut.

Flood wave levels within this reach vary from El. 90± to El. 80± with related depths of flow ranging from 10 to 5 feet at site of residential homes. Calculated flows are about 15,000± cfs, 1,000 feet downstream of the dam, and 5,300± cfs at 9,800 feet below the dam.

The areas of probable impact include scattered residential homes along Millbrook Road and East Main Street. In addition, State Highway Route 155 is located 3,500± feet downstream of the dam. The number of dwellings in the probable impact area is approximately 20. It should be noted that the failure of the dam at this site in 1961 caused significant economic loss but no loss of life. Approximately 15 houses are in area where flooding depths of 1 to 3 feet (above first floor levels) are estimated. About 3 houses would have flooding of 3 to 5 feet. About two houses would have flooding of 5 to 10 feet.

SECTION 6 - EVALUATION OF STRUCTURAL STABILITY

6.1 VISUAL OBSERVATIONS:

No evidence was observed indicating structural instability of the embankment dam.

6.2 DESIGN AND CONSTRUCTION DATA:

Sufficient data is not available on the soil properties and design and construction of the earth embankment to permit a formal evaluation of stability. The design data reviewed, however, does not point to any sources or areas of structural instability.

6.3 POST-CONSTRUCTION CHANGES:

A comparison of the visual appearance of the dam and the record drawings indicate that no major modifications have been made to the dam.

6.4 SEISMIC STABILITY:

This dam is in Seismic Zone 1, and in accordance with the recommended guidelines of the Corps of Engineers does not warrant seismic analysis.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

a. Condition. A visual inspection and a review of available design information indicate that Crystal Lake Dam is in generally fair condition and functioning adequately. No immediate actions to remedy any serious problems are required.

The total capacity of the water control structure is adequate to pass the PMF test flood outflow of 184 cfs without overtopping the dam (compare 196 cfs to 184 cfs).

b. Adequacy of Information. The evaluation of the dam is mainly based on the results of the visual inspection assisted by the general physical dimensions provided in the available contract drawings.

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 following items should be performed under the direction of a Qualified Registered Engineer:

a. Develop methods to monitor and ensure proper operation of the pressure relief wells.

b. Develop methods of determining potential for seepage through the dam.

7.3 REMEDIAL MEASURES:

a. Operating and Maintenance Procedures. The owner should:

1) Maintain clear of trees and brush the dam embankment, an area within 25 feet of the downstream toe, and the outlet channel for a distance of 100 feet downstream from the dam.

2) Engage a Qualified Registered Engineer to make a comprehensive technical inspection once every year.

3) Establish a surveillance program for use during and immediately after heavy rainfall and also a warning program to follow in case of emergency conditions.

4) Remove grate or provisions for quick release at outlet end of 36 in. diameter pipe.

7.4 ALTERNATIVES:

There are no practical alternatives to the recommendations presented in 7.2 and 7.3 above.

APPENDIX A

INSPECTION CHECK LIST

INSPECTION CHECK LIST

PARTY ORGANIZATION

PROJECT Crystal Lake Dam, Middletown DATE Oct. 1, 1979

TIME 1200

WEATHER Sunny 60°F

W.S. ELEV.____ U.S.____ DN.S.

PARTY:

1. R.Smith, FGA, Project Manager
2. P. Burgess, FGA, Hydraulics/Hydrology
3. R. Murdock, GEI, Geotechnical
4.
5.

PROJECT FEATURE	INSPECTED BY	REMARKS
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

PERIODIC INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Crystal Lake Dam, CT DATE: Oct. 1, 1979

AREA EVALUATED	CONDITIONS
DAM EMBANKMENT	
Crest Elevation	
Current Pool Elevation	
Maximum Impoundment to Date	Unknown.
Surface Cracks	None.
Pavement Condition	Grassy surface, path 15" wide, 3" rut across dam.
Movement or Settlement of Crest	None.
Lateral Movement	None observed.
Vertical Alignment	Good.
Horizontal Alignment	Good.
Condition at Abutment and at Concrete Structures	Some minor erosion along dam adjacent to left abutment.
Indications of Movement of Structural Items on Slopes	None.
Trespassing on Slopes	Rockfill downstream face, riprap paving upstream.
Sloughing or Erosion of Slopes or Abutments	
Rock Slope Protection - Riprap Failures	None observed
Unusual Movement or Cracking at or near Toes	None.
Unusual Embankment or Downstream Seepage	None.
Piping or Boils	None.
Foundation Drainage Features	Drawing indicates downstream drainage blanket.
Toe Drains	Downstream drainage blanket.
Instrumentation System	Possible piezometer.
Vegetation	Grass along crest.

PERIODIC INSPECTION CHECK LIST

NATIONAL DAM INSPECTION PROGRAM

DAM: Crystal Lake Dam

DATE: Oct. 1, 1979

AREA EVALUATED	CONDITIONS
DIKE EMBANKMENT	Not applicable.
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	
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	
Vegetation	

PERIODIC INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Crystal Lake Dam DATE: Oct. 1, 1979

AREA EVALUATED	CONDITIONS
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	Underwater
a. Approach Channel	
Slope Conditions	
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
b. Intake Structure	Concrete above water in good condition, valve stems appear in good condition. No valve operators.
Condition of Concrete	
Stop Logs and Slots	Underwater.

PERIODIC INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Crystal Lake Dam, CT. **DATE:** Oct. 1, 1979

AREA EVALUATED	CONDITIONS
OUTLET WORKS - CONTROL TOWER	Not applicable.
a. Concrete and Structural	
General Condition	
Condition of Joints	
Spalling	
Visible Reinforcing	
Rusting or Staining of Concrete	
Any Seepage or Efflorescence	
Joint Alignment	
Unusual Seepage or Leaks in Gate Chamber	
Cracks	
Rusting or Corrosion of Steel	
b. Mechanical and Electrical	
Air Vents	
Float Wells	
Crane Hoist	
Elevator	
Hydraulic System	
Service Gates	
Emergency Gates	
Lightning Protection System	
Emergency Power System	
Wiring and Lighting System in Gate Chamber	

PERIODIC INSPECTION CHECK LIST

NATIONAL DAM INSPECTION PROGRAM

DAM: Crystal Lake Dam DATE: Oct. 1, 1979

AREA EVALUATED	CONDITIONS
OUTLET WORKS - TRANSITION AND CONDUIT	Not applicable.
General Condition of Concrete	
Rust or Staining on Concrete	
Spalling	
Erosion or Cavitation	
Cracking	
Alignment of Monoliths	
Alignment of Joints	
Numbering of Monoliths	

PERIODIC INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Crystal Lake Dam **DATE:** Oct. 1, 1979

AREA EVALUATED	CONDITIONS
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	
General Condition of Concrete	Excellent condition, no evidence of deterioration.
Rust or Staining	None.
Spalling	None.
Erosion or Cavitation	None.
Visible Reinforcing	None.
Any Seepage or Efflorescence	None.
Condition at Joints	
Drain Holes	None observed.
Channel	Natural soil and gravel bottom.
Loose Rock or Trees Overhanging Channel	Trees and rocks overhanging channel on both banks.
Condition of Discharge Channel	Considerable trees, brush and trash located in channel downstream of outlet works.

PERIODIC INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Crystal Lake Dam DATE: Oct. 1, 1979

AREA EVALUATED	CONDITIONS
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	
General Condition	Upstream face of the dam underwater.
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Approach Channel	
b. Weir and Training Walls	
General Condition of Concrete	
Rust or Staining	
Spalling	
Any Visible Reinforcing	
Any Seepage or Efflorescence	
Drain Holes	None.
c. Discharge Channel	
General Condition	Same as outlet channel.
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Channel	
Other Obstructions	

PERIODIC INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Crystal Lake Dam, CT. DATE: Oct. 1, 1979

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

APPENDIX B

ENGINEERING DATA

ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

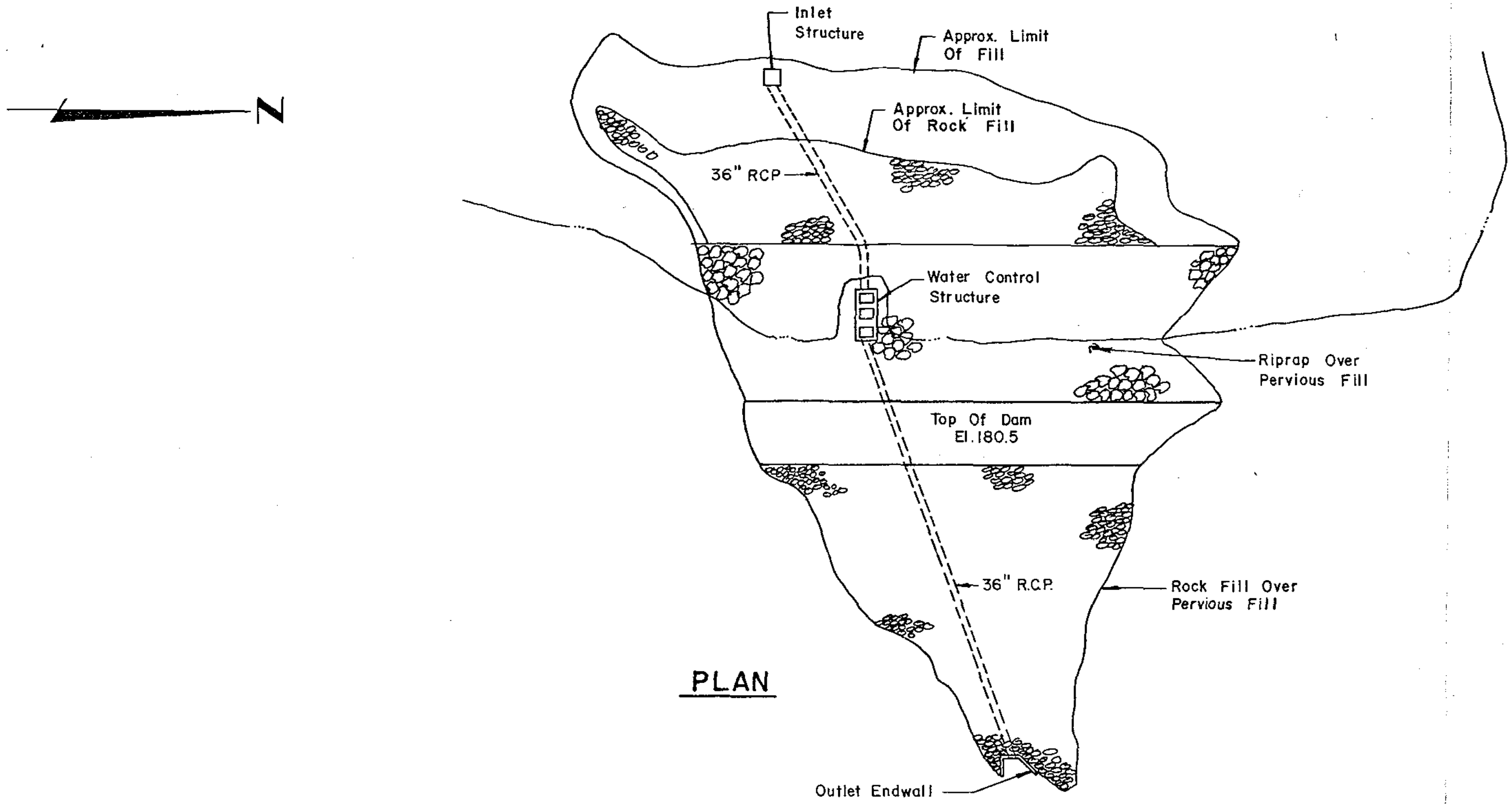
I.D. NO. CT-00138

ITEM	REMARKS
AS-BUILT DRAWINGS	CONSTRUCTION PLANS - DEP FILES
REGIONAL VICINITY MAP	AVAILABLE FROM U.S.G.S.
CONSTRUCTION HISTORY	LIMITED DATA - DEP FILES
TYPICAL SECTIONS OF DAM	FROM PLANS
OUTLETS - Plan	FROM PLANS
- Details	FROM PLANS
- Constraints	UNKNOWN
- Discharge Ratings	DESIGN DATA SHOWN ON PLANS
RAINFALL/RESERVOIR RECORDS	UNAVAILABLE
DESIGN REPORTS	LIMITED DATA - DEP FILES
GEOLOGY REPORTS	NONE
DESIGN COMPUTATIONS	
HYDROLOGY & HYDRAULICS	DESIGN DATA SHOWN ON PLANS
DAM STABILITY	LIMITED DATA - DEP FILES
SEEPAGE STUDIES	LIMITED DATA - DEP FILES
MATERIALS INVESTIGATIONS	
BORINGS RECORDS	SHOWN ON PLANS
LABORATORY	NONE
FIELD	NONE

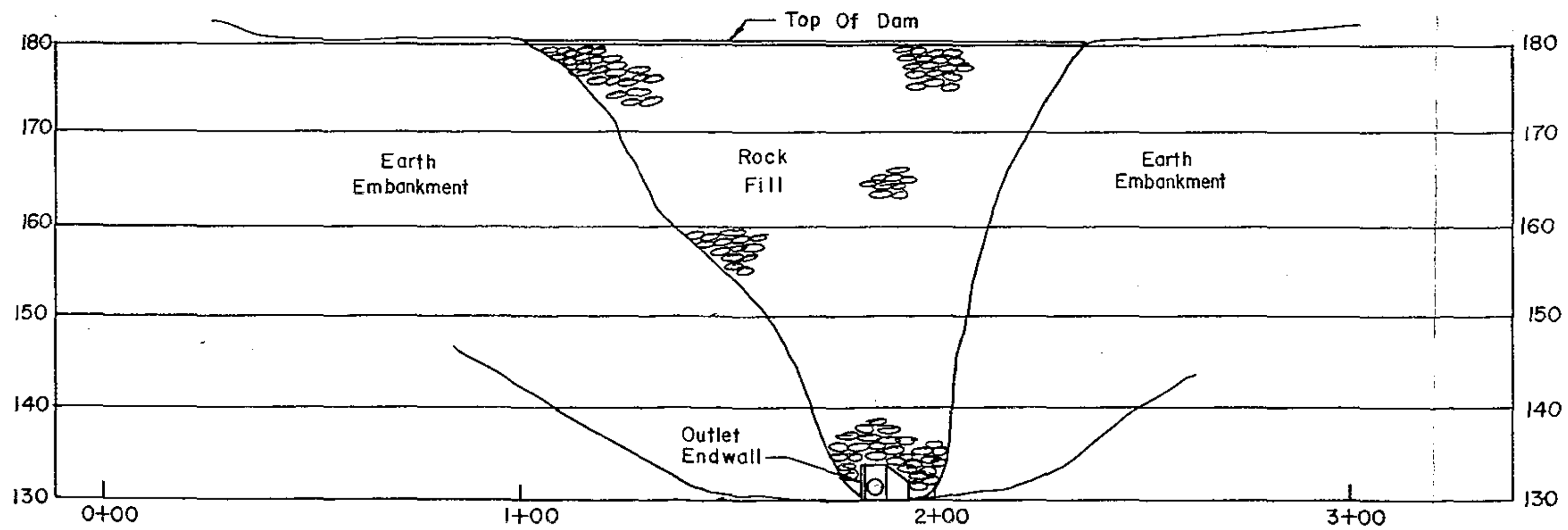
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

I.D. NO. CT-00138

ITEM	REMARKS
POST-CONSTRUCTION SURVEYS OF DAM	NONE AVAILABLE
BORROW SOURCES	UNKNOWN
MONITORING SYSTEMS	UNKNOWN
MODIFICATIONS	UNKNOWN
HIGH POOL RECORDS,	NONE
POST-CONSTRUCTION ENGINEERING STUDIES AND REPORTS	LIMITED DATA - DEP FILES
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	DAM AT THIS SITE FAILED - APRIL 27, 1961 NEWSPAPER REPORTS - DEP FILES
MAINTENANCE OPERATION RECORDS	NONE
SPILLWAY PLAN	
SECTIONS	FROM PLANS
DETAILS	FROM PLANS
OPERATING EQUIPMENT PLANS & DETAILS	FROM PLANS



PLAN

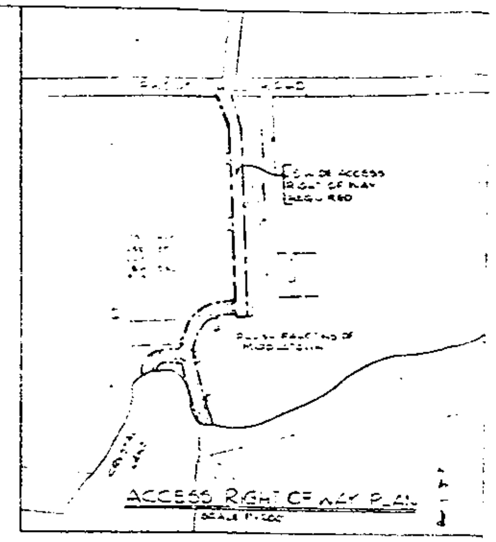


DOWNSTREAM ELEVATION OF DAM

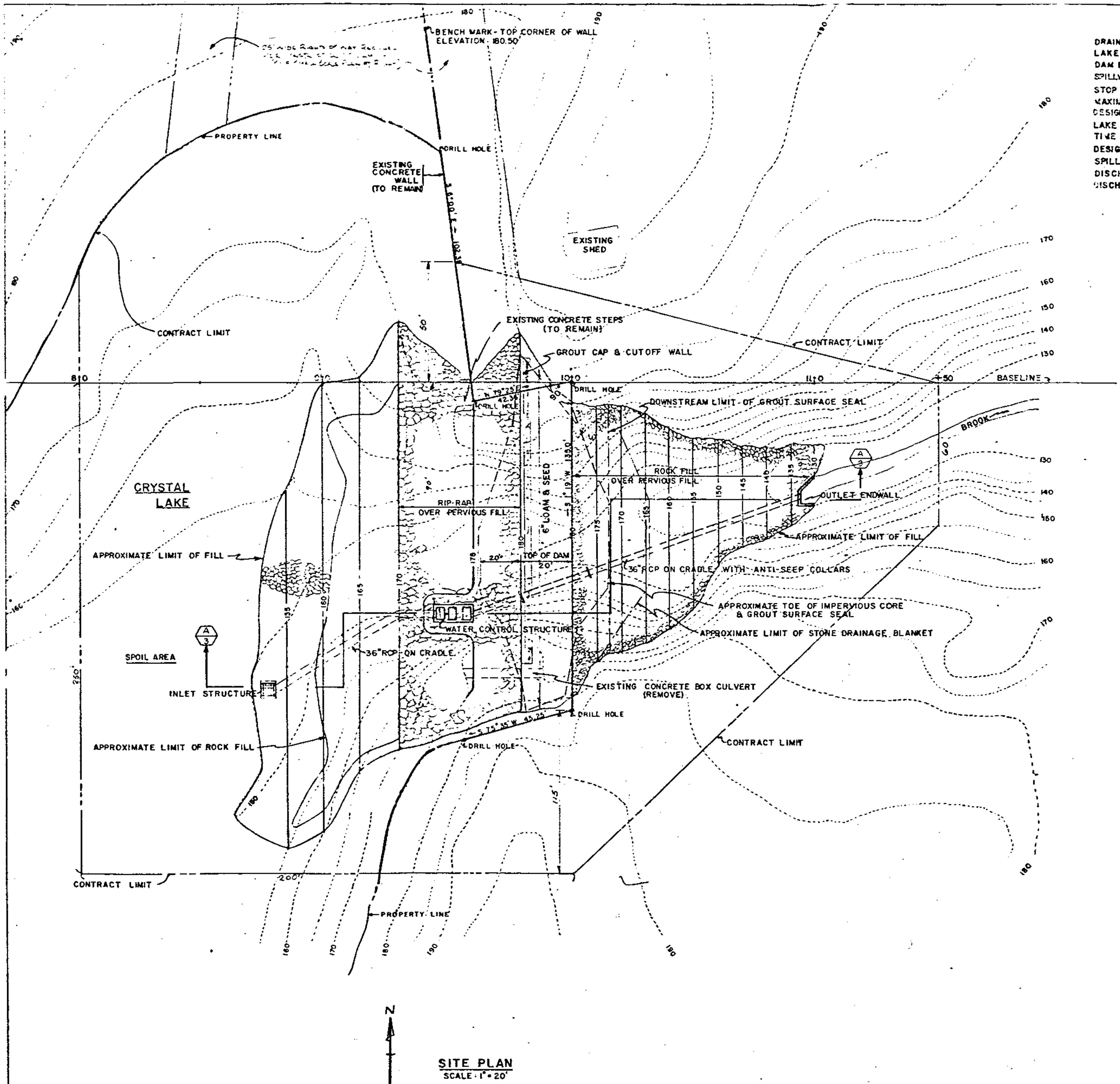
CRYSTAL LAKE DAM

DESIGN DATA

DRAINAGE AREA	200 ACRES
LAKE AREA	33 ACRES
DAM ELEVATION	180.5 FT.
SPILLWAY ELEVATION	175.0 FT.
STOP LOG CONTROL TO ELEVATION	165.0 FT.
MAXIMUM DRAWDOWN ELEVATION	155.0 FT.
DESIGN STORM RAINFALL	4 IN/HR
LAKE STORAGE (100% RUNOFF) AT ELEVATION 177.0'	4 IN. RAINFALL
TIME OF CONCENTRATION	54 MIN.
DESIGN RUNOFF COEFFICIENT	0.33
SPILLWAY WIDTH	6 FT.
DISCHARGE AT 2' HEAD	55 CFS
DISCHARGE WITH GATES OPENED AT 25' HEAD	100 CFS



ACCESS RIGHT OF WAY PLAN



SITE PLAN
SCALE: 1" = 20'

NOTE

PLANS BASED ON MAP ENTITLED "CONTOUR PLAN OF PORTION OF CRYSTAL LAKE MIDDLETOWN, CONN. PROJECT NO BI-BB-53, DATED DECEMBER, 1962, SCALE: 1"=20', PREPARED BY CHANDLER AND PALMER, ENG'RS, NORWICH, CONN., FOR THE STATE OF CONN."

REDUCED NOT TO SCALE

SITE PLAN

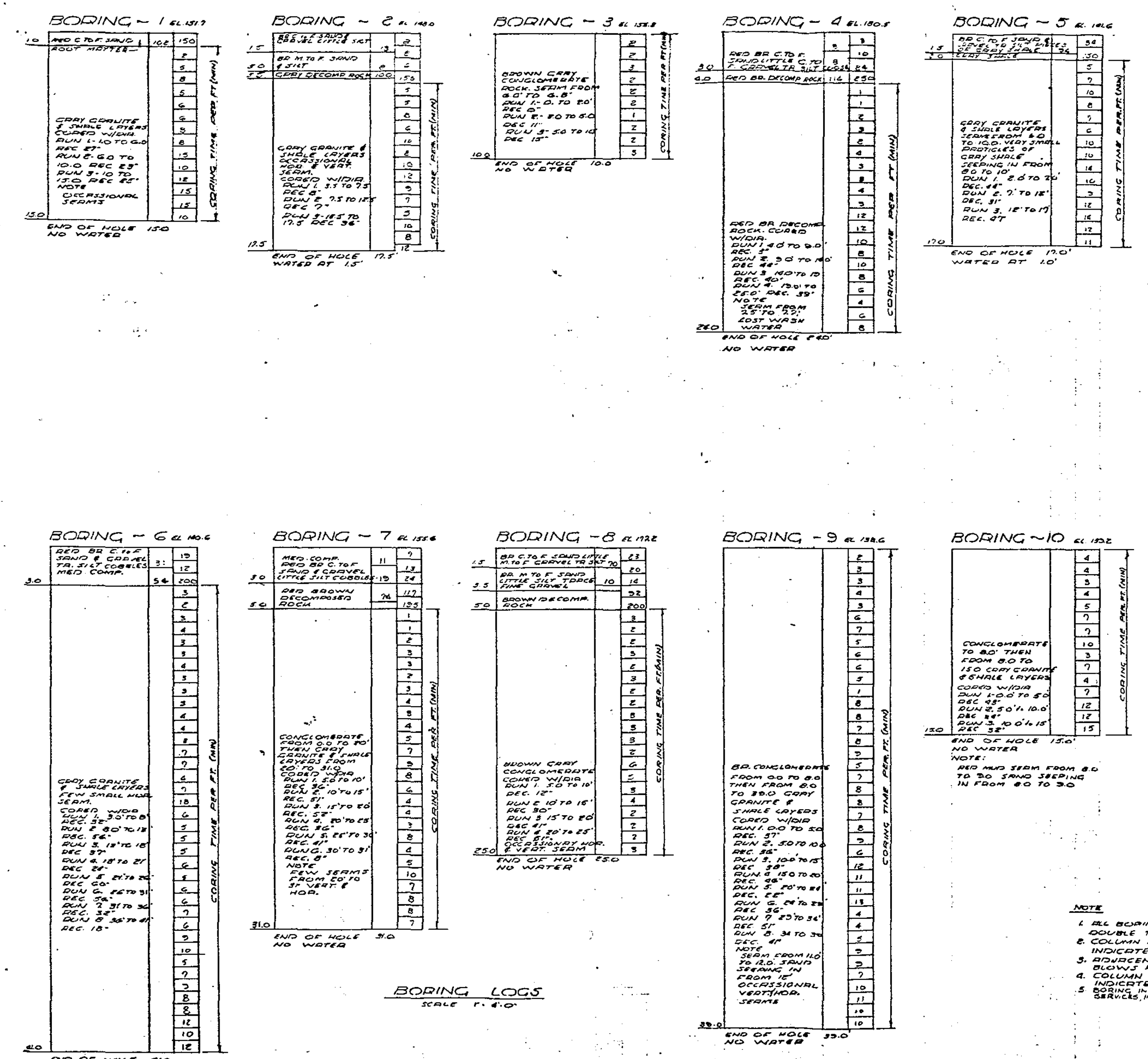
STATE OF CONNECTICUT
PUBLIC WORKS DEPARTMENT
T. J. MURPHY, JR., COMMISSIONER

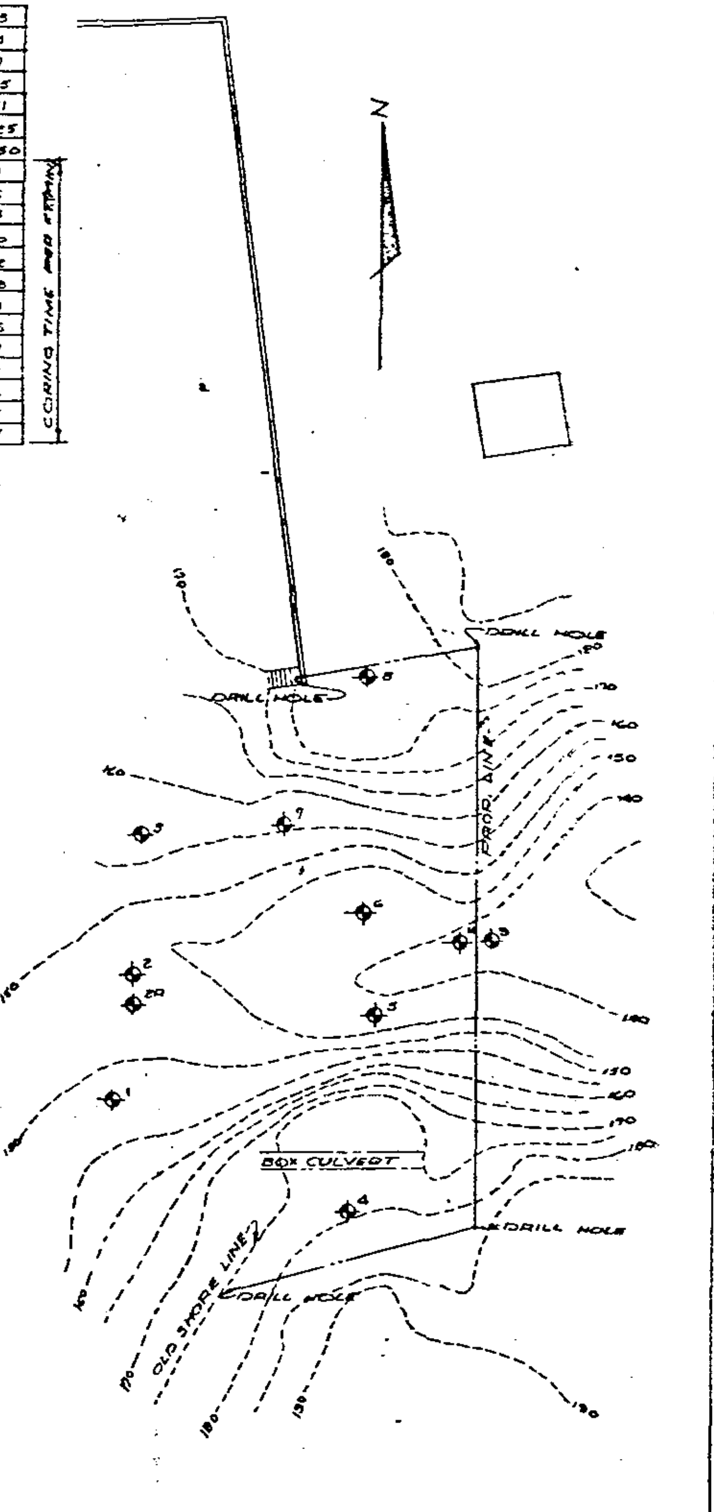
DRAWN BY: SJM	CONSTRUCTION OF DAM	PROJECT NO: BI-BB-53
CHECKED: RPL	CRYSTAL LAKE	DRAWING NO: 1
APPROVED: AHC	MIDDLETOWN, CONNECTICUT	

REVISIONS		
NO	DESCRIPTION	DATE

PLANS PREPARED BY
ONDERDONK AND LATHROP
CONSULTING ENGINEERS
GLASTONBURY, CONNECTICUT

SCALE: AS NOTED
DATE: 16 SEPT 1963





LOCATION PLAN

SCALE 1" = 20'

NOTE

1. ALL BORING DONE WITH SERIES "M" DOUBLE TUBE CORE BARREL.
2. COLUMN AT EXTREME RIGHT OF LOGS INDICATES ROCK CORING TIME IN MIN. PER FT.
3. ADJACENT COLUMN TO THE LEFT INDICATES BLOWS PER FOOT ON 2" SPLIT SPOON SAMPLER.
4. COLUMN AT EXTREME LEFT OF LOGS INDICATES STRATA CHANGE.
5. BORING INFORMATION FURNISHED BY ENGINEERING SERVICES, INC., GLASTONBURY, CONN., MARCH, 1963.

REDUCED NOT TO SCALE

BORINGS

REVISIONS		
NO	DESCRIPTION	DATE

STATE OF CONNECTICUT
PUBLIC WORKS DEPARTMENT
T. J. MURPHY, JR. COMMISSIONER

DRAWN BY J.E.A.
CHECKED R.P.L.
APPROVED C.B.F.

CONSTRUCTION OF DAM
CRYSTAL LAKE
MIDDLETOWN CONNECTICUT

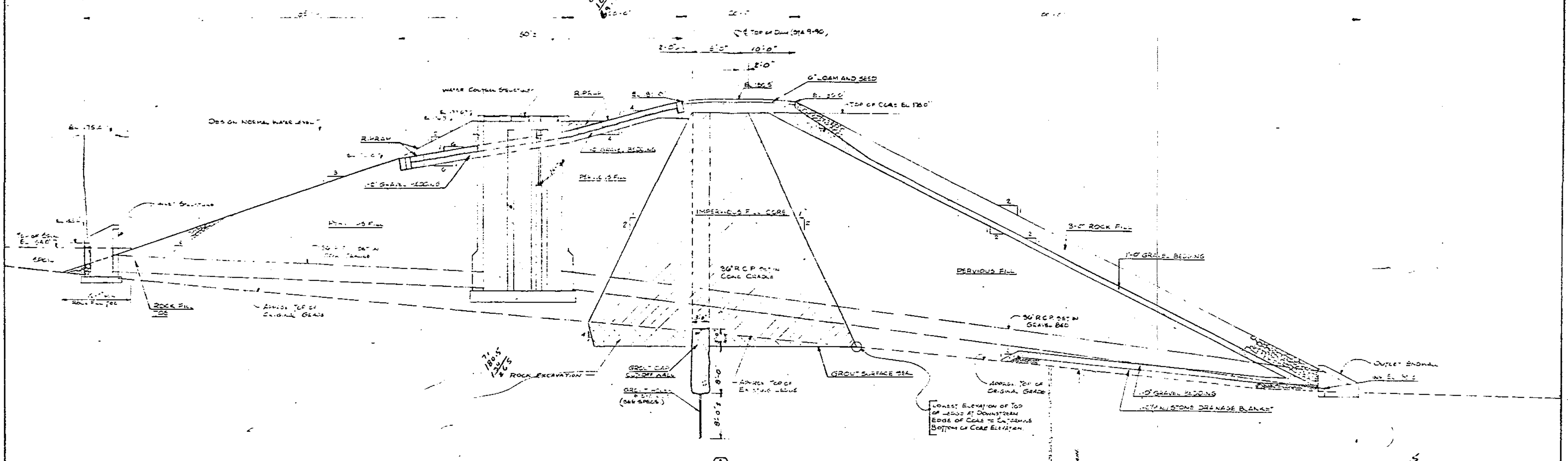
BI-SB-53

2

PLANS PREPARED BY
ONDERDONK AND LATHROP
CONSULTING ENGINEERS
GLASTONBURY, CONNECTICUT

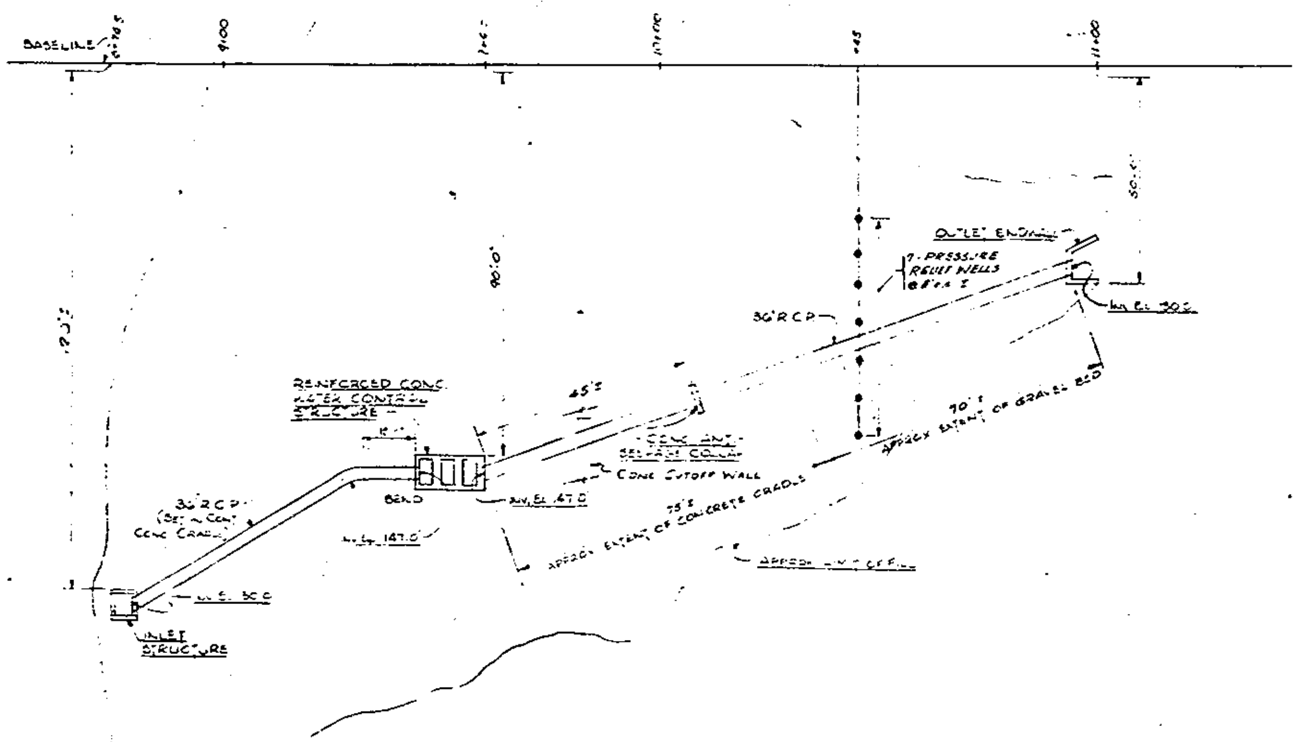
SCALE AS NOTED

DATE 16 SEPT. 1963



SECTION (A/3) THROUGH DAM

SCALE: 1/8" = 1'-0"



PLAN SHOWING PIPING

SCALE: 1" = 20'

REDUCED NOT TO SCALE

DAM SECTION & PIPING

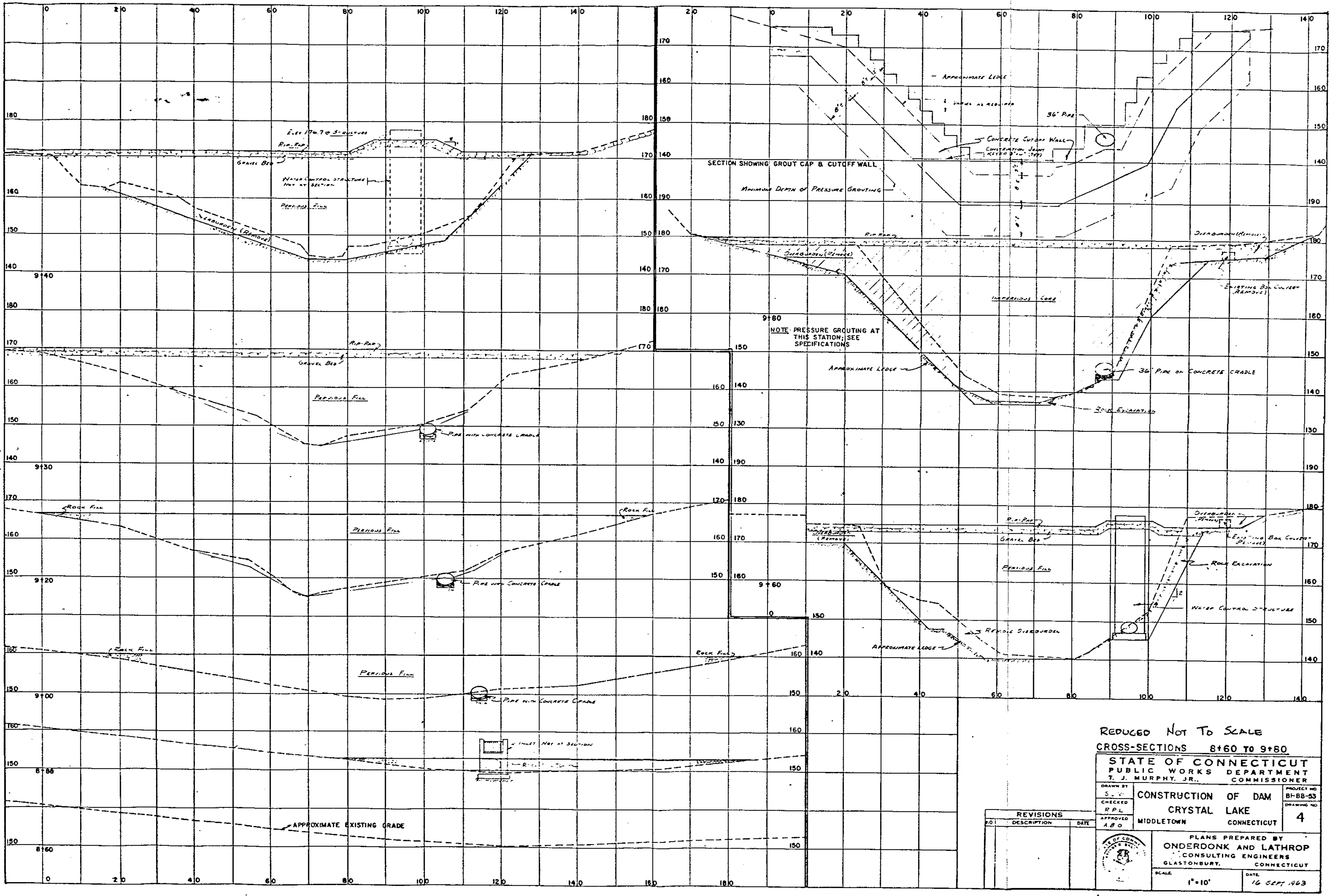
REVISIONS		
NO.	DESCRIPTION	DATE

STATE OF CONNECTICUT
PUBLIC WORKS DEPARTMENT
T. J. MURPHY, JR., COMMISSIONER

DRAWN BY R.A.G.	CONSTRUCTION OF DAM	PROJECT NO. BI-BB-53
CHECKED R.P.L.	CRYSTAL LAKE	DRAWING NO. 3
APPROVED A.B.O.	MIDDLETOWN CONNECTICUT	

PLANS PREPARED BY
ONDERDONK AND LATHROP
CONSULTING ENGINEERS
GLASTONBURY, CONNECTICUT

SCALE: AS NOTED
DATE: 16 SEP 1963



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CROSS-SECTIONS 8+60 TO 9+80

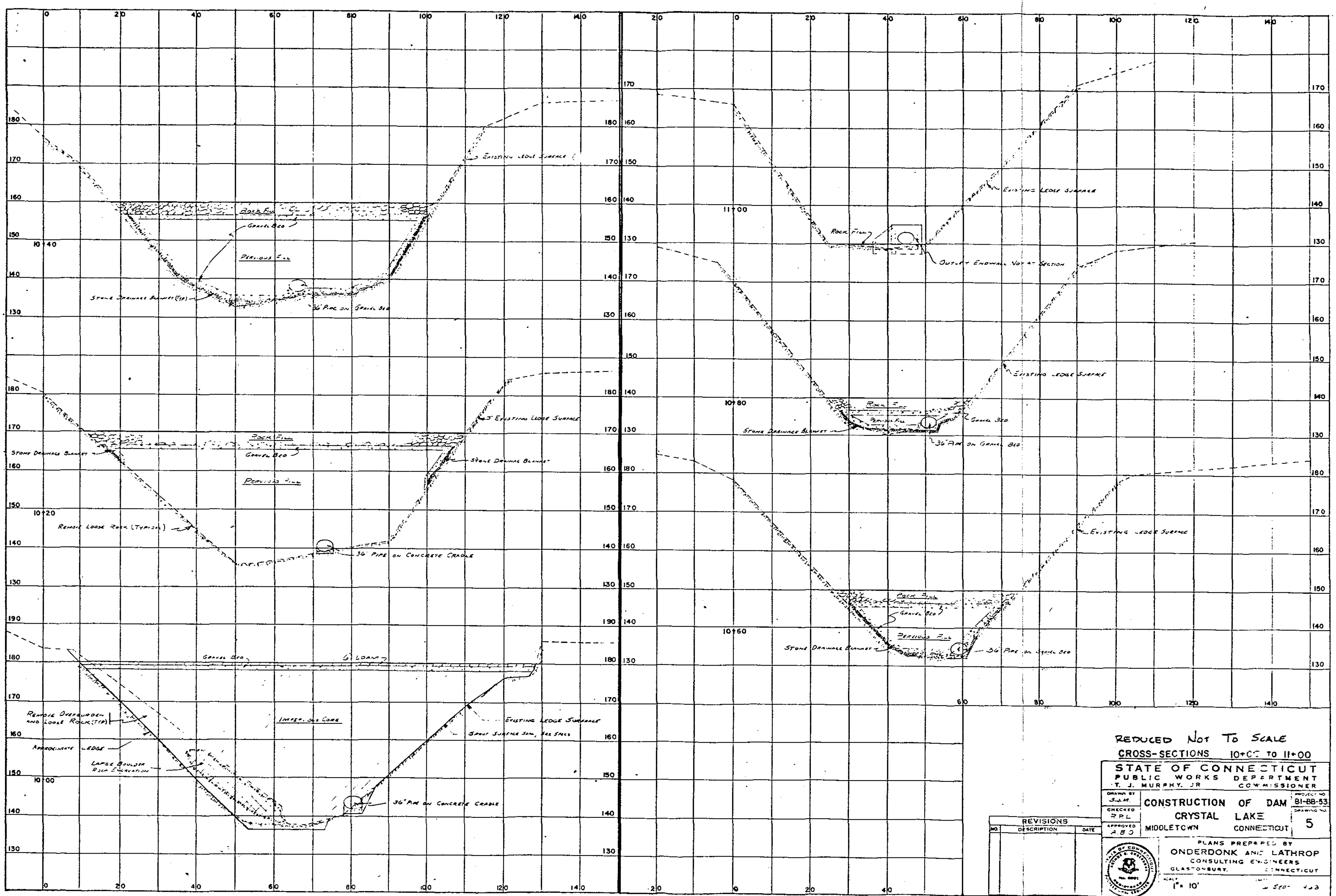
STATE OF CONNECTICUT
PUBLIC WORKS DEPARTMENT
T. J. MURPHY, JR., COMMISSIONER

DRAWN BY S.V.	CONSTRUCTION OF DAM	PROJECT NO. BI-BB-53
CHECKED R.P.L.	CRYSTAL LAKE	DRAWING NO. 4
APPROVED A.B.O.	MIDDLETOWN CONNECTICUT	

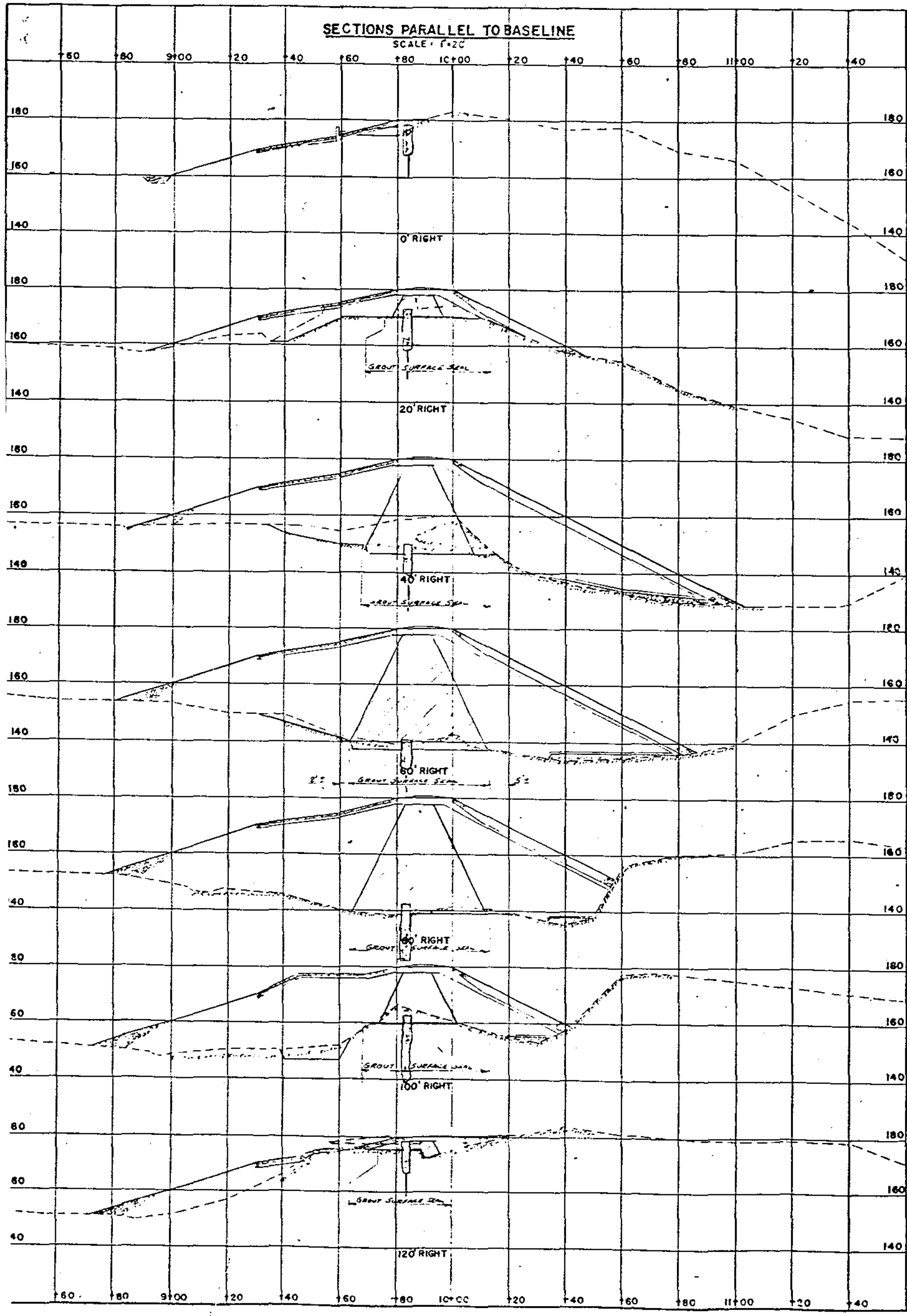
REVISIONS		
NO.	DESCRIPTION	DATE

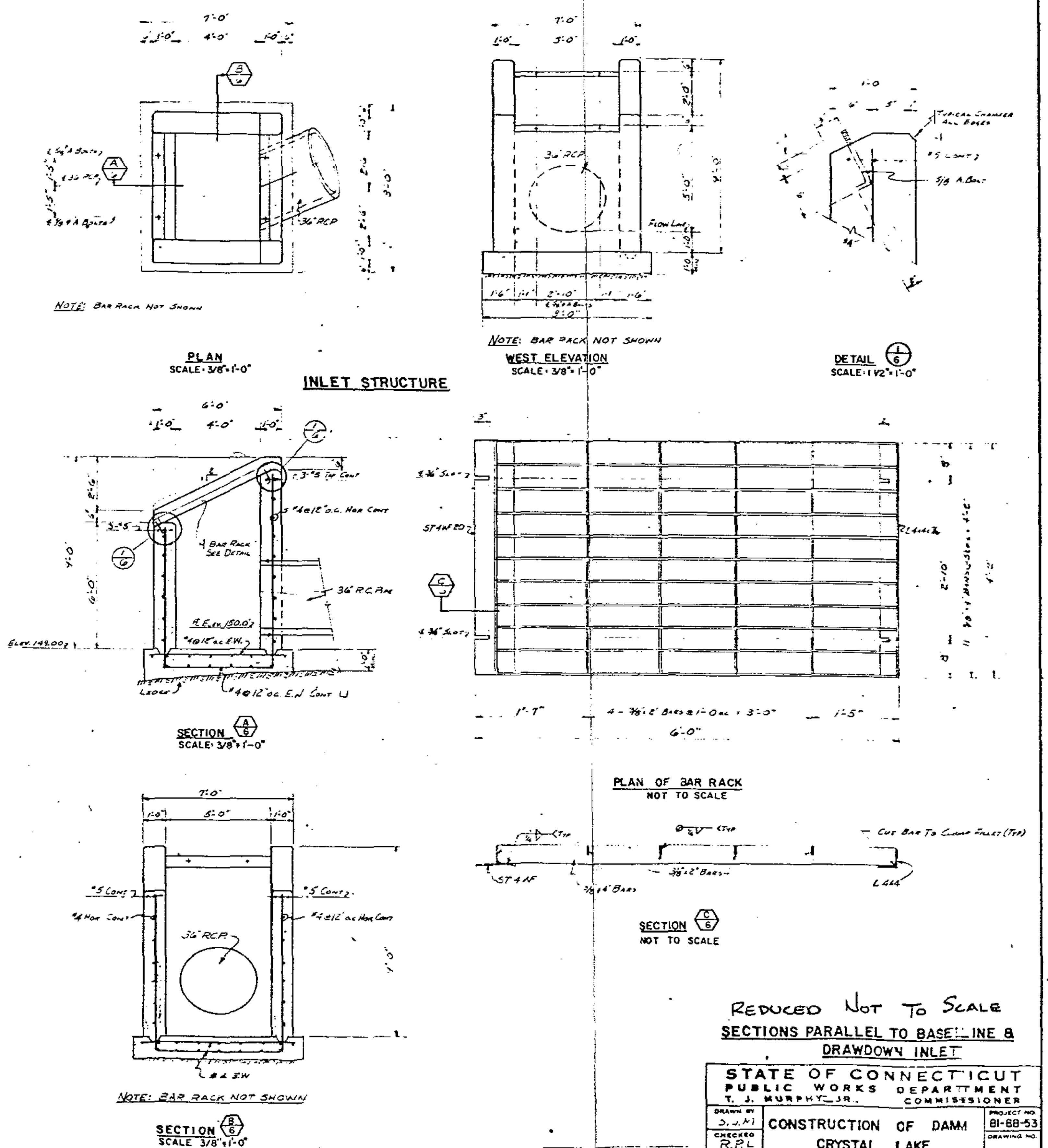
PLANS PREPARED BY
ONDERDONK AND LATHROP
CONSULTING ENGINEERS
GLASTONBURY, CONNECTICUT

SCALE 1" = 10'
DATE 16 SEPT. 1963



10+40
Rock Fill
Gravel Bed
Pervious Fill
Stone Drainage Blanket (Typ)
36" Pipe on Gravel Bed
Existing Ledge Surface
10+20
Stone Drainage Blanket
Pervious Fill
Remove Loose Rock (Typical)
36" Pipe on Concrete Cradle
10+00
Gravel Bed
6" Loam
Impervious Core
Remove Overburden and Loose Rock (Typ)
Approximate Ledge
Large Boulder Rock Excavation
36" Pipe on Concrete Cradle
Existing Ledge Surface
Grout Surface Seam, See Specs
11+00
Rock Fill
Outlet Endwall Not at Section
10+80
Stone Drainage Blanket
36" Pipe on Gravel Bed
10+60
Stone Drainage Blanket
36" Pipe on Gravel Bed
REDUCED NOT TO SCALE
CROSS-SECTIONS 10+00 TO 11+00
STATE OF CONNECTICUT
PUBLIC WORKS DEPARTMENT
T. J. MURPHY, JR COMMISSIONER
DRAWN BY S.J.M.
CHECKED R.P.L.
APPROVED A.B.O.
CONSTRUCTION OF DAM
CRYSTAL LAKE
MIDDLETOWN CONNECTICUT
PROJECT NO. BI-88-53
DRAWING NO. 5
REVISIONS
NO. DESCRIPTION DATE
PLANS PREPARED BY
ONDERDONK AND LATHROP
CONSULTING ENGINEERS
GLASTONBURY, CONNECTICUT
SCALE 1" = 10'





Reduced Not To Scale

SECTIONS PARALLEL TO BASELINE & DRAWDOWN INLET

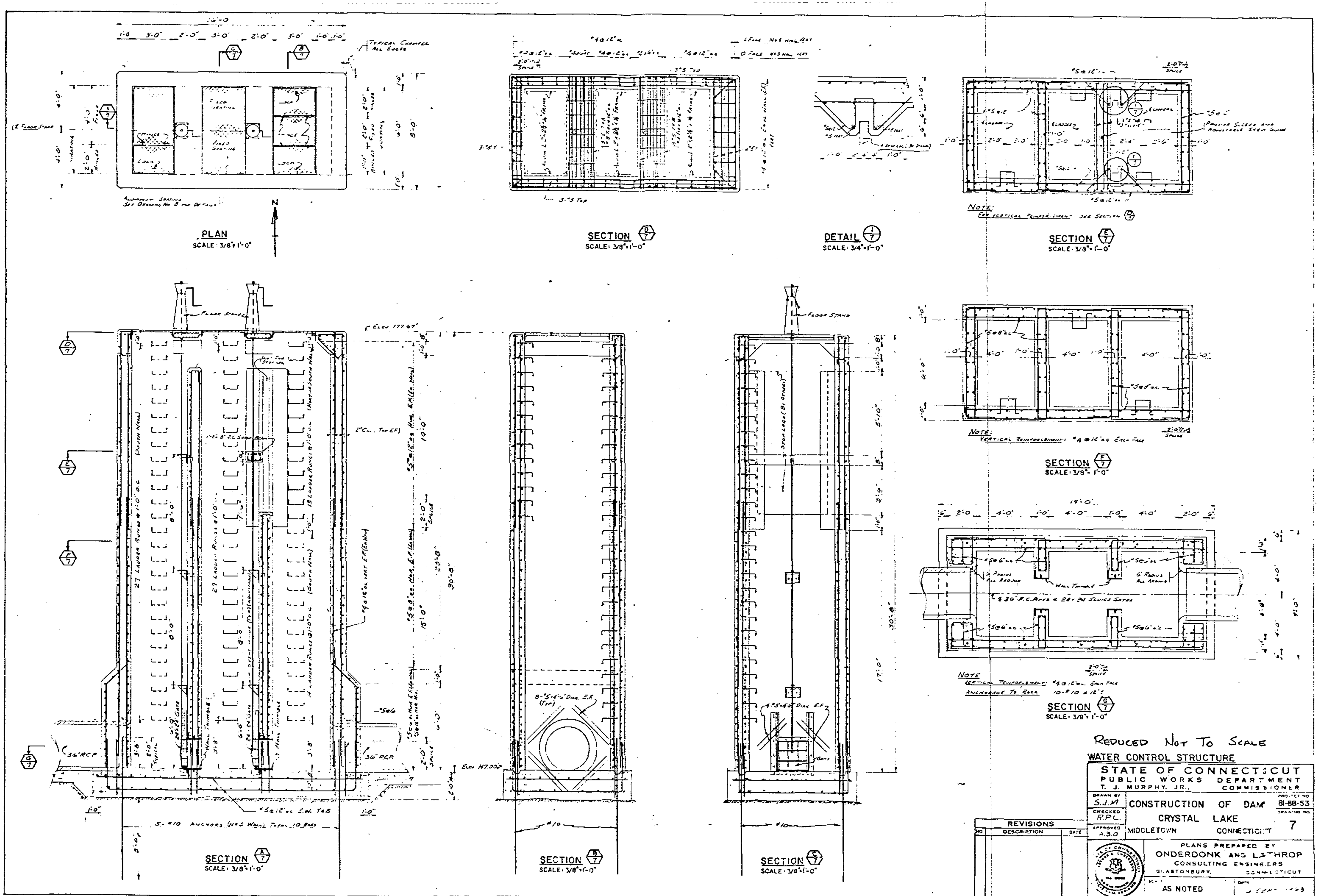
REVISIONS	
NO.	DESCRIPTION

STATE OF CONNECTICUT
PUBLIC WORKS DEPARTMENT
T. J. MURPHY, JR. COMMISSIONER

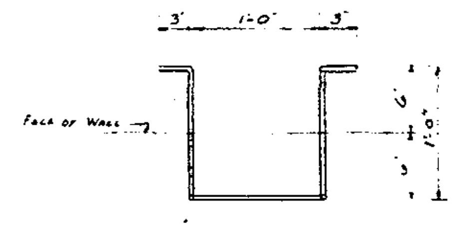
DRAWN BY S.J.M.	CONSTRUCTION OF DAMM	PROJECT NO. 81-88-53
CHECKED R.P.L.	CRYSTAL LAKE	DRAWING NO. 6
APPROVED A.B.O.	MIDDLETOWN CONNECTICUT	

PLANS PREPARED BY
ONDERDONK AND LATHROP
CONSULTING ENGINEERS
GLASTONBURY CONNECTICUT

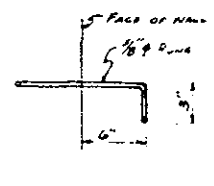
SCALE: AS NOTED
DATE: 1963



PLAN
SCALE: 3/8"=1'-0"
SECTION D/7
SCALE: 3/8"=1'-0"
DETAIL 1/7
SCALE: 3/4"=1'-0"
SECTION E/7
SCALE: 3/8"=1'-0"
SECTION F/7
SCALE: 3/8"=1'-0"
SECTION G/7
SCALE: 3/8"=1'-0"
SECTION A/7
SCALE: 3/8"=1'-0"
SECTION B/7
SCALE: 3/8"=1'-0"
SECTION C/7
SCALE: 3/8"=1'-0"
REDUCED NOT TO SCALE
WATER CONTROL STRUCTURE
STATE OF CONNECTICUT
PUBLIC WORKS DEPARTMENT
T. J. MURPHY, JR. COMMISSIONER
DRAWN BY S.J.M
CHECKED R.P.L.
APPROVED A.3.O
CONSTRUCTION OF DAM
CRYSTAL LAKE
MIDDLETOWN CONNECTICUT
PROJECT NO 81-88-53
DRAWING NO. 7
REVISIONS
NO. DESCRIPTION DATE
PLANS PREPARED BY
ONDERDONK AND LATHROP
CONSULTING ENGINEERS
GLASTONBURY, CONNECTICUT
AS NOTED

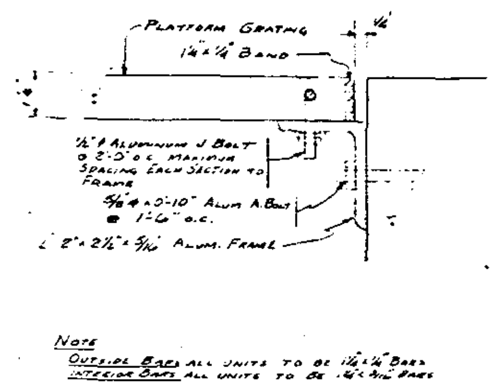


PLAN

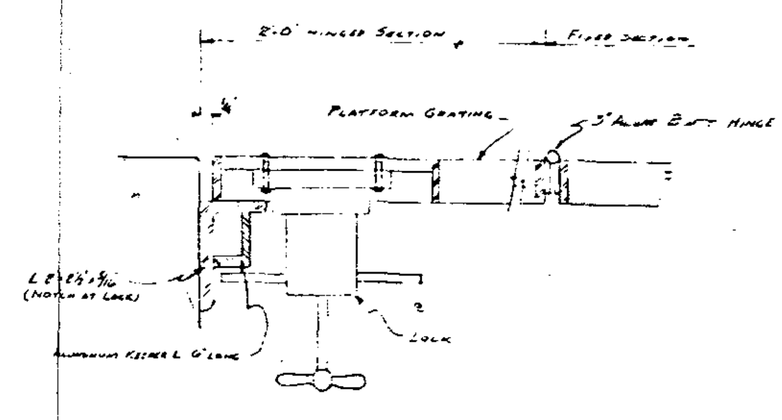


SECTION

LADDER RUNG DETAIL
SCALE: 1 1/2" = 1'-0"

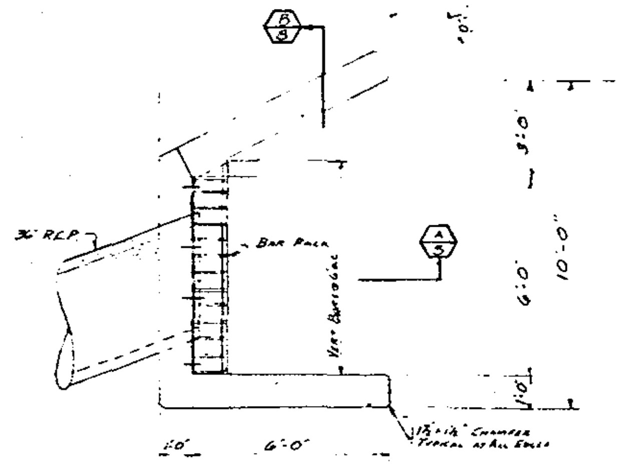


FIXED SECTION

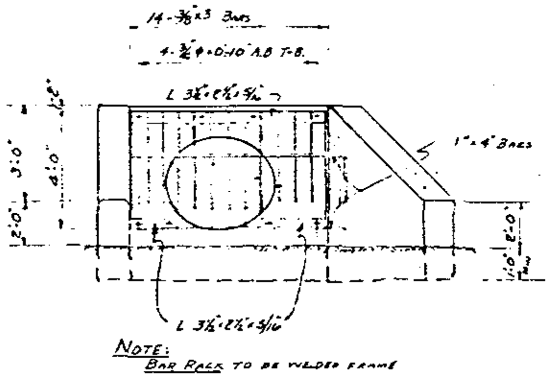


HINGED SECTION

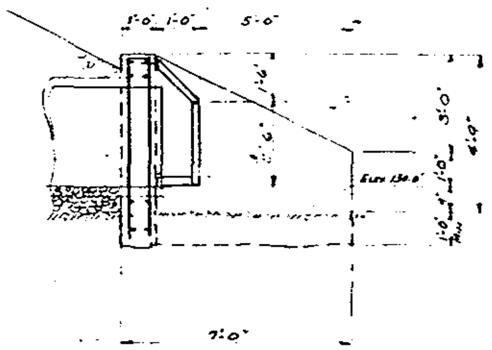
PLATFORM GRATING DETAILS
NOT TO SCALE



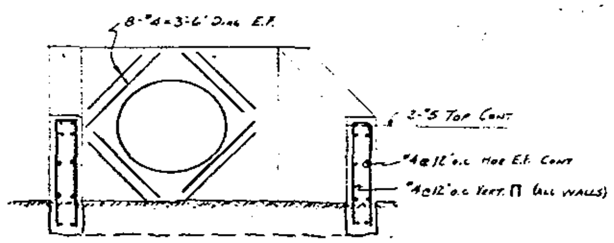
PLAN



EAST ELEVATION

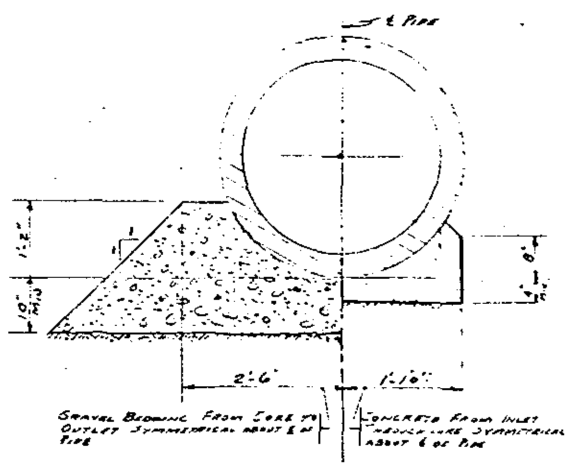


SECTION A/6

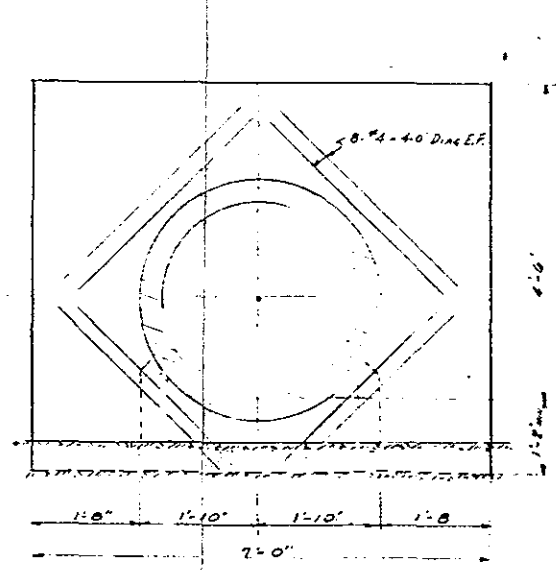


SECTION B/8

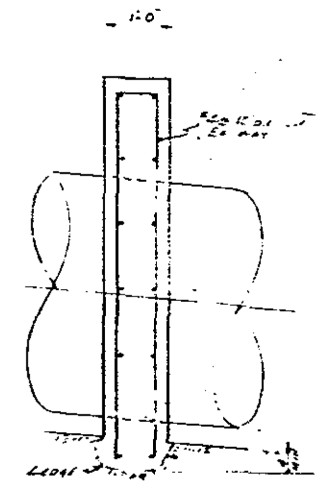
OUTLET ENDWALL DETAILS
SCALE: 3/8" = 1'-0"



PIPE CRADLE DETAIL
SCALE: 3/4" = 1'-0"



ELEVATION



SECTION

ANTI-SEEP COLLAR DETAILS
SCALE: 3/4" = 1'-0"

REDUCED NOT TO SCALE

OUTLET ENDWALL & MISC. DETAILS

STATE OF CONNECTICUT
PUBLIC WORKS DEPARTMENT
T. J. MURPHY, JR., COMMISSIONER

DRAWN BY S.J.M	CONSTRUCTION OF DAM	PROJECT NO. BI-88-53
CHECKED RPL	CRYSTAL LAKE	DRAWING NO.
APPROVED ABD	MIDDLETOWN CONNECTICUT	8

REVISIONS

NO.	DESCRIPTION	DATE

PLANS PREPARED BY
ONDERDONK AND LATHROP
CONSULTING ENGINEERS
GLASTONBURY, CONNECTICUT

SCALE: AS NOTED
DATE: 1963

HARTFORD TIMES - APRIL 27, 1961

Crystal Lake Leaves Sea of Mud in Wake

By DENNIS RILEY
Times Staff Writer

Middletown — The Crystal Lake Dam burst here before dawn today, sending millions of gallons of water pouring into lowlands over an area of several square miles.

Three persons were slightly injured and 11 homes were damaged.

About 50 persons in 15 families were evacuated from the flooded section after the dam gave way at 2:45 a. m.

Samuel G. Cannon, superintendent of Public Works, estimated damage to houses alone at $100,000.

John C. O'Brien, deputy superintendent of Public Works, set $50,000 as a preliminary estimate of highway damage. Personal property, utility services and farms also were hit.

A bridge over a small brook was washed out.

Mayor Harry T. Clew, later this morning, called on the Federal Housing and Home Finance Agency to declare a flood section here a disaster area. He requested a field representative to come Friday to inspect the damage.

* * *

THE SCENE was described as a "nightmare" in the Millbrook Rd. and Prout Hill Rd. sections.

Some persons were "washed out of their homes" and then hung onto fences until they were rescued, police said.

Police were notified in a phone call from Mrs. Mary V. Gilbert, a resident affected.

Policemen, firemen, Public Works personnel, Red Cross units and utilities employes helped in the rescue.

Chief Michael Milardo of the South Fire District company, said the flood peak came at 3:15 and lasted briefly. By 3:30, he said, water started to recede.

* * *

THE LAKE WAS about a mile long, up to 60 feet deep and 500 feet across at its greatest width.

All that remains are puddles. The lake had been used for swimming and fishing activities in a Falcon Park recreation program.

The dam itself, about 60 feet high and 40 feet wide, was a brownstone arch structure. Skindivers had checked it in recent days.

Spokesmen at the Russell Manufacturing Co. said previous findings were that Winter frost had damaged the dam wall. Russell has water rights to the pond.

Superintendent Cannon said no official finding has been made on the cause of the break.

* * *

TREATED at Middlesex Memorial Hospital for shock, scratches and abrasions were Mrs. Connie Geremia, in her 40s; her daughter Cheryl, 14 and Miss Carol Imme, 40, identified as Mrs. Geremia's sister.

Reported flooded were the houses of Lou Petruzello, George Clegg, Lewis Angi, Albert Geremia, Joseph Ciaburri, Louis Russo, Loy Hoyle, Edward Landell, Thomas Eastwood and Charles Gilbert.

The home of Michael Champey was less seriously damaged, Chief Milardo reported. About six autos were washed away.

The lake, on a hill, was fed from foothills south of Prout Hill Rd., Mr. Cannon said.

When the dam broke the water rushed down and first hit the Landell Poultry Farm. It next struck the Gilbert home, the the others, rushed past the Russell Manufacturing Co. and on into the Connecticut River.

A brook carried the waters harmlessly past a low section of the Russell plant.

CLEANUP CREWS and newsmen poured in as flood waters susbsided.

"Don't bother to wipe your feet," one stoic resident said as a newspaperman entered his home. He found a half-inch of mud covering the entire downstairs, his cellar completely flooded, and six inches of water left in the bottom drawers of furniture and appliances as the water level went down.

At Crystal Lake this morning, dozens of youngsters scoured the mud flats, once the lake bottom, looking for fish and souvenirs.

Boats left tied last night to shortline docks were hanging, suspended by their mooring lines, over a gaping chasm of mud.

"They knew for years this would happen," one old-timer said. "When my father built his house there in the valley, years ago, they tried to stop him."

Cleanup crews were plagued by bogged trucks and snarls of tree limbs and rubbish. Police had difficulty routing traffic and curious spectators around the disaster area.

STATE OF CONNECTICUT

WATER RESOURCES COMMISSION

STATE OFFICE BUILDING - HARTFORD, CONNECTICUT 06115

Crystal Lake Dam, Middletown

Summary of File

October 17, 1946 - Letter from T. M. Russell, Russell Mfg. Co., stating that Crystal Lake Dam had been leaking during summer and repairs contemplated. Inquiry as to procedure.

November 5, 1946 - Received preliminary application form for proposed repairs. No plans.

November 22, 1946 - Memo from J. Curry to Richard Martin, Chairman, W. R. C., describing leak and potential of damage downstream.

November 26, 1946 - Letter from B. H. Palmer, Member State Board of Supervisor of Dams, to Russell Mfg. Co., outlining a procedure for determining repairs to be made.

January 30, 1947 - Letter from B. H. Palmer to Richard Martin, S. B. of S. of Dams, describing repairs almost completed, and opining that certificate of approval would not be necessary since work did not involve structural changes.

February 10, 1949 - Letter from B. H. Palmer to Russell Mfg. Co., advising them of "substantial leak in the dam" and suggesting that pond be lowered to facilitate repair. "The dam is in no danger of failing."

August 2, 1955 - Letter from B. H. Palmer to Russell Mfg. Co., attention of Mr. Wilson, stating that on this date the writer observed a substantial leak in the dam. Estimated that leak had been running for two or three months but not longer than that. Recommends excavation to determine location of leak.

November 12, 1957 - Letter of report from B. H. Palmer to W. R. C., suggesting certain repairs to dam.

April 27, 1961 - Dam failed.

April 27, 1961 - Report of damage to Highway Route 155 by Robert A. Norton. Copy attached to and filed with memo to M. Wayne dated January 16, 1962.

May 12, 1961 - Report of dam failure from J. Curry to W. Wise.

May 16, 1961 - Letter from W. S. Wise to Russell Mfg. Co., advising them that as a result of W.R.C. meeting on May 15 ... "you as the reported owner of this dam to take immediate steps to correct the hazardous conditions at the site." - i.e., embankments.

May 18, 1961 - Letter from Russell Mfg. Co. to W. Wise - question of their ownership, etc.

June 5, 1961 - Memo to Walter T. Schuler from Edward F. Harris regarding property search and defining Russell Mfg. as owners of dam.

November 27, 1961 - Memo J. Curry to Commissioner J. Gill "concerning the Interest of the W.R.C. and its Predecessor Agencies in the Crystal Lake Dam."

January 15, 1962 - Copy of entire folder sent to:

Mr. Robert P. Volpe
Attorney at Law
75 Pearl St.
Hartford, Conn.

March 15, 1962 - Copy of entire folder sent to:

Mr. Louis Johnson
Attorney at Law
Main St.
Middletown, Conn.

May 2, 1963 - Memo from H. G. Hunt, Chief, Design and Review of Public Works Dept. to W. S. Wise - "Enclosed are final plans" (for dam).

May 20, 1963 - Report from A. J. Macchi, Engineers, acting as consultant to W.R.C., commenting on design by Onderdonk and Lathrop.

May 29, 1963 - Reply by Onderdonk and Lathrop to design comments.

June 6, 1963 - Letter from A. J. Macchi to W.R.C., summarizing meeting with design engineers.

June 25, 1963 - Letter from Onderdonk and Lathrop to W.R.C., replying to A. J. Macchi's comments.

July 10, 1963	- Letter from A. J. Macchi, answering comments of Onderdonk and Lathrop.
September 5, 1963	- Letter from Onderdonk and Lathrop mentioning changes in design as proposed by Clarence Welti, Soil Engineer.
September 26, 1963	- Memo from H. G. Hunt to W. S. Wise - "Enclosed is a final submission on the above project."
October 17, 1963	- Letter from A. J. Macchi, commenting on revised plans.
November 6, 1963	- Memo from M. R. Case, Assistant Chief Engineering, Public Works Dept., to J. Curry - enclosing letter (comments) by both Onderdonk and Lathrop and Clarence W. Welti.
November 27, 1963	- Letter from A. J. Macchi with comments on letter from Clarence Welti.
December 10, 1963	- Letter from Onderdonk and Lathrop to T. J. Murphy, Commissioner, P. W. Dept., commenting on A. J. Macchi's reviews.
January 28, 1964	- Memo from J. Curry to Timothy J. Murphy, Jr., suggesting ways of completing negotiations.
February 26, 1964	- Letter from T. J. Murphy, Jr., to Onderdonk and Lathrop asking them to revise plans.
March 6, 1964	- Application for Construction Permit with Revised plans.
March 11, 1964	- Letter to W.R.C. from A. J. Macchi recommending approval.
March 24, 1964	- Construction Permit issued for dam.
April 11, 1966	- Letter to W.R.C. from A. J. Macchi recommending that a Certificate of Approval be issued.
April 27, 1966	- Certificate of Approval issued on this dam.

[V]ERDONK & LATHROP
[CON]SULTING ENGINEERS
[GLAS]TONBURY, CONN.

May 29, 1963

A. John Macchi, P. E.
44 Gillett Street
Hartford, Connecticut

Re: Construction of Dam
Crystal Lake
Middletown, Connecticut

Dear Mr. Macchi:

Your recommendations of May 20, 1963, based upon review of the plans and specifications for this project are appreciated. Our comments are as follows:

Item 1. An analysis of the design made by our Soils Engineer, Professor Karl Hendrickson (University of Massachusetts), indicates a safety factor of 2.7 against sliding compared to a usual safety factor of 1.5 to 1.7 in earth work of this nature.

Item 2. Professor Hendrickson is of the opinion that the placing of the grout cap two feet into the rock may not be necessary, but it is conservative and will make the concrete seal somewhat more effective.

This office will include this item in the plans if funds permit. The extra cost, involving the removal of approximately 35 cu. yds. of rock and replacing with concrete, would amount to about $1,600.00.

Item 3. Riprap was not provided around the outlet end wall of the 36" R.C.P. as the end wall will be in rock and the adjacent slopes are covered with rock fill.

Item 4. It is the opinion of our engineers that elimination of the top ladder rungs and replacing with a short hinged ladder, is not necessary for the following reasons:

(a) The area provided for flow at the top of the chamber is much greater than required. Icing up of the rungs would be a negligible factor for flow.
(b) Maintenance would be increased by having a hinged ladder.
(c) Extra cost involved.

General. We are enclosing for your information three reports by Professor Hendrickson:

(a) Report dated April 26, 1963, based upon review of the basic plans and specifications. His suggestions were incorporated in the final plans and specifications.

(b) Report dated May 15, 1963, based upon review of the final plans and specifications. His suggestions will be incorporated in the contract documents.

(c) Report and Sliding Analysis dated May 24, 1963, based upon A. J. Macchi's review comments of May 20, 1963.

If there are any further comments, please call this office.

Yours very truly,

A. B. Onderdonk

A. Bruce Onderdonk, P. E.

ABO/c
encs.

cc. w/enc.
Public Works Department
Water Resources Commission

Comments on

Crystal Lake Dam
Middletown, Connecticut

April 26, 1963

Foundation Comments:

1. Rock: Weathered sandstone and shale with frequent seams of weathered siltstone which id poorly consolidated.

2. This site is unsuitable for masonry dams.

3. The rock and earth dam shown best suits the site.

Seepage:

1. The site will always have minor seepage along the bedding seams of the rock. The loss of water, in itself, is not of concern sinwe previous reservoir history indicates that the leaks are not greater than the inflow.

2. Since the dip of the bedding directs water flow deeply, danger of uplift exists only in the area directly below the centerline of the proposed dam.

3. As a basic design principle, good watertightness about the core and upstream when coupled with free and comppete drainage of all portions of the downstream embankment foundation will assure stability with respect to both leakage and uplift.

4. Seepage along the conduit within the core is adequately cared for in the design. Founding the conduit on a concrete bed resting on rock, and installing the seep fins as shown is satisfactory.

Core:

1. The cross-section of the core is satisfactory for the material proposed. Seepage loss through the core will be in the order of 10 to 20 cubic feet per day. ?

2. Rock treatment at the core section by grouting will improve the watertightness. A grput curtain made up of holes 5' on center, 15' deep on the floor of the site and 10' deep normal to the walls will materially reduce foundation and abutment leakage.

3. A 3' wide plain concrete cut-off stepped in such a way that no part of the top is less than 2' from the foundation, and each piece is keyed to its neighbor will reduce the piping liability along the rock contact.

4. All parts of the exposed rock in contact with the core must have dental treatment to fill seams and cracks where the core might erode.

Core (continued)

3. The top of the core should be covered with processed gravel to break capillarity on its crest.

Upstream Shell Embankment:

1. Suggest adding a rock toe and filter along edge of embankment.

2. Provide a [illegible] gravel blanket beneath the riprap.

3. All other details are conservative.

Downstream Shell Embankment:

1. Provide drainage blanket between rock foundation and pervious fill.

2. Consider using clean-up rock and rock excavation as the downstream embankment to its economic limit.

Karl N. Hendrickson
Foundation Engineer

Karl N. Hendrickson
Foundation Engineer
56 Berkshire Terrace
Amherst, Massachusetts

May 15, 1963

Onderdonk and Lathrop, Consulting Engineers
2512 Main Street
Glastonbury, Connecticut

Re: Crystal Lake Dam in Middletown

Dear Bruce,

I have reviewed the subject plans and specifications and have the following comments:

1. Specs. Div 6, Sect 2 and 3. Use additional words to show that opt. density is related to Standard Proctor, ASTM D698-57T, or AASHO Standard.

2. It may be necessary to drop from 95% to 90% in the impervious section because of the limited working space.

3. Hand tamping with pneumatic or gas tools may be needed aroung the conduit and at uneven spots on the ledge.

4. The first grouting holes on the west abutment may reveal that grouting the west abutment is unnecessary. (See Bore Holes 678 and9.)

5. If a situation exists where the intake could be plugged, the overflow structure empty, and the reservoir full, uplift on the bottom of the structure becomes critical and will require a couple of rock anchors.

All other features appear satisfactory and safe.

I leave for Colorado on June 1, and hope that you and Bob have a summer as interesting and enjoyable as mine promises to be.

Best wishes,

Karl Hendrickson
Foundation Engineer

RECEIVED
ONDERDONK & LATHROP
CONSULTING ENGINEERS
GLASTONBURY, CONN.

Karl N. Hendrickson
Civil Engineer
56 Berkshire Terrace
Amherst, Massachusetts

May 24, 1963

Onderdonk & Lathrop, Consulting Engineers
2512 Main Street
Glastonbury, Connecticut

RE: Crystal Lake Dam - Sliding Analysis

Dear Bruce:

I have just completed the sliding analysis of the Crystal Lake Dam suggested by comments in the report by Macchi, and find a safety factor of 2.7 which indicates that no additional "locking or keying" is necessary.

My assumptions are that a section at 60+R is critical and that no strength is derived from the friction with the abutments. The uplift diagram is based on reasonable efficiency of grouting, and cracks which interconnect the strata of the shale and sandstone on the east foundation. That these strata dip about 21° in the north direction makes my assumption of shale deterioration the conservative one.

The placing of the group cap 2' into the rock may not be necessary, but it is conservative and will make the concrete wall somewhat more effective. I have ignored the extra slide strength furnished by this feature.

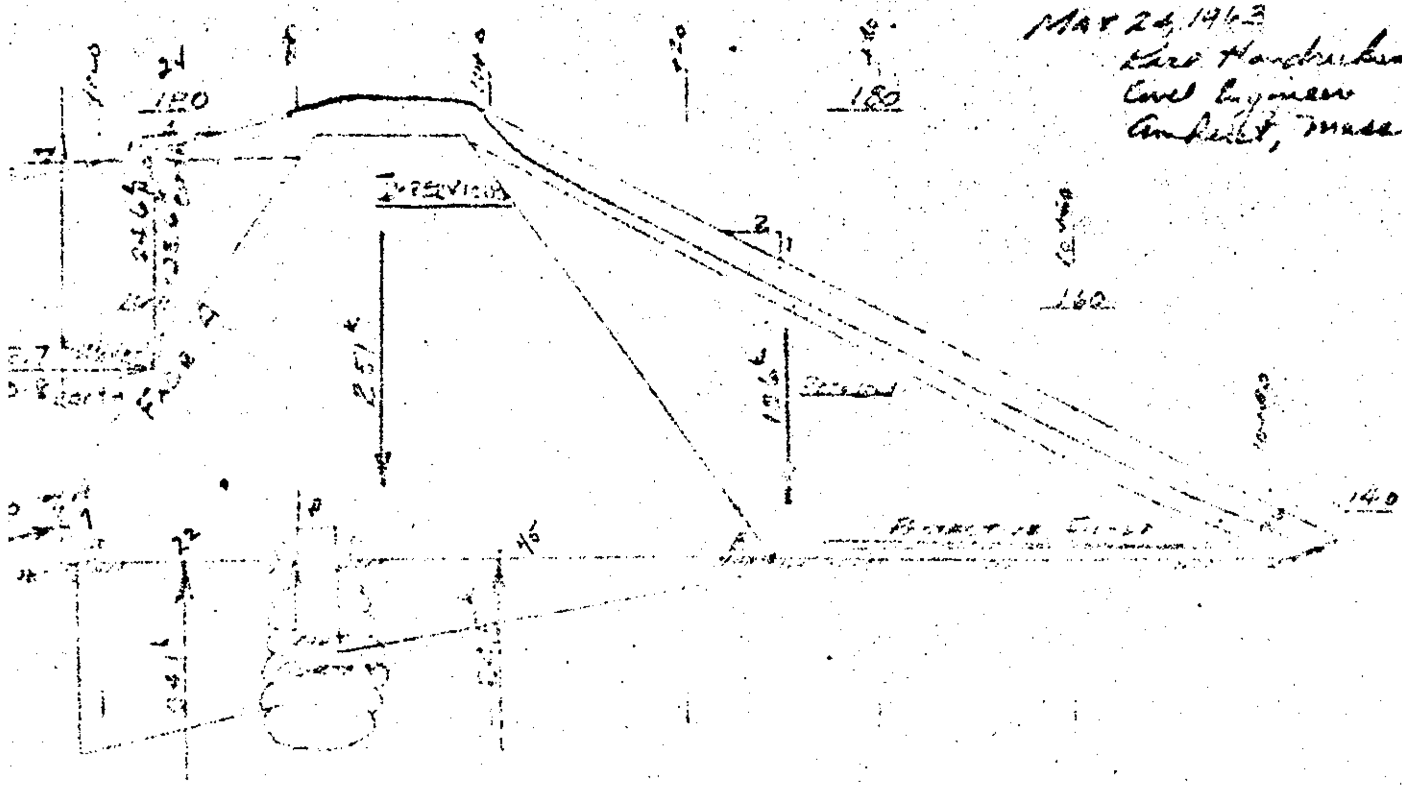
A usual safety factor of 1.5 to 1.7 in earth work of this nature is the lowest acceptable.

Best wishes,

Karl N. Hendrickson

SLIDING ANALYSIS

CRYSTAL LAKE DAM
MIDDLETOWN, CONN
MAY 24, 1963
[illegible signature]
Civil Engineer
Amherst, Mass.



Section [illegible]
Scale [illegible]

[illegible]:
Σ vertical forces [illegible] ↓
Σ horizontal forces [illegible] →

Resultant [illegible]

Friction available:
Assuming
A. Shale adhesion diminishes, φ = 22° (fine sand)
F = N tan φ = 372.6 × .415 [illegible]

SAFETY FACTOR = [illegible] = 2.7

B. Shale remains competent (φ = 38°) ([illegible] for sand)
F = N tan φ = 372.6 × .78 = [illegible]

SAFETY FACTOR = [illegible]/55.5 = 5.2

CONCLUSION: SAFE WITH RESPECT TO SLIDING

Stability Analysis
Crystal Lake Dam
Middletown Conn
May 24, 1963
K.M.H.

Forces for Sliding Block Calculations

a. Uplift due to neutral pressure (See free body on p2)

Point	Elements	Pressure	Force
A	$33' \times \gamma_w$	= 2050 psf	$= 7' \times 1955$ (1980) = **13.7**^{k}
B	$33 \times \frac{13}{14} \gamma_w$	1910	22×1550 (1650) = **34.1**^{k} ↑
C	$33 \times \frac{9.5}{14} \gamma_w$	1390	
D	$33 \times \frac{6.5}{14} \gamma_w$	950	45×545 (545) = **24.5**^{k} ↑
E	$33 \times \frac{1}{14} \gamma_w$	140	

b. Neutral Pressure on Face A

Horizontal $\frac{1}{2} \times 33^2 \times \gamma_w$ = **33.7**^{k} → ✓

Vertical $\frac{1}{2} \times 33 \times 20 \times \gamma_w$ = **24.6**^{k} ↓ ✓

c. Earth Pressure on Face A (Assume $\phi = 30°$)

Horizontal $\frac{1}{2} \gamma H^2 K_p = \frac{1}{2} \times 33^2 \times 60 \times \frac{1}{3}$ = 10.8^k

Vertical $\frac{1}{2} \times 33' \times 24' \times \frac{\gamma_b}{60}$ = 23.6^k ↓

d. Weight of Impervious Section Assume γ_c = 130 pcf

(1) $24 \times 45 \times \frac{1}{2} \times 130$ = 70^k
(2) $16 \times 45 \times 130$ = 93
(3) $30 \times 45 \times \frac{1}{2} \times 130$ = 88
251^k

251^k ↓

e. Weight of Downstream Embankment Assume γ_t = 110 pcf

$55 \times 45 \times \frac{1}{2} \times 110$ = 136^k ↓

Summation

Horizontal	Vertical ↑	Vertical ↓
11	3	24.6
33.7	34.1	23.6
10.8	24.5	251.0
55.5^k →	**61.6**^{k} ↑	136.0
		434.2^k ↓

NET **372.6**^{k} ↓

P. O. Box 473
Idaho Springs, Colorado

June 19, 1963

Onderdonk and Lathrop, Engineers
Glastonbury, Connecticut

Re: Crystal Lake Dam - Middletown

Dear Bruce,

Sorry my report on the items listed was not complete enough to answer the questions raised at the conference.

Referring to the June 6, 1963, letter which had the June 5 minutes listed, I will attempt explanations of those points questioned:

1. "This site is unsuitable for a masonry dam"

   The borings indicate that the rock on the west side of the site is firm and less weathered. It is a fairly hard and competent conglomerate resting on hard basement. Site inspection also makes the difference noticeable. The west side of the ravine is steeper and more sound. The rock on the east is shale and sandstone with seams which are weathered and soft. Disregarding, for the moment, the strike and dip of the shale and sandstone, this means that a masonry dam, a rigid structure which has relatively high foundation pressures, would be bearing on rock part of which has a lower modulus than the rest. Fluctuations of the reservoir level causes up and down stress values. The resulting strains are not as reversible elastically and there would be progressive damage on the east side. The only design remedy for such a situation is a combination of upstream blanket, extensive grouting, and relief wells. The earth dam has much greater contact area, and is somewhat flexible, and therefore, more adaptable to sites with poor foundations.

   This is the main basis for my quoted statement.

2. "Are the assumptions in the sliding analysis completely justified?"

   My critical assumptions are listed below with the current reasoning.

   a. Ø, angle of friction, of disintegrated shale and sandstone = 22°. This is not the result of a test, but is an estimate based on tests I have performed on similar material. This is possibly my weakest assumption.

   b. A seepage net could be separately for the core and for the foundation beneath it if the permeability of the foundation material is different.

      If the permeability of the foundation is greater than that of the core of the dam, and this is the only critical foundation problem, then the uplift pressure of the water on the dam may be estimated graphically. The figures on the free body at 60' R are based on a flow net, assumed unit weights of the moist compacted soil, thrust due to static water pressure, and active earth pressure on the upstream face.

The Ø for the intact rock in contact with soil is assumed, due to the specified foundation treatment, to be that of the soil, 38° is an average value in this area.

Sluicing. This item of concern to Mr. Macchi is a very real one, and in an earth dam is called piping (sometimes backward erosion). The same danger is present in a masonry dam where the contact between the masonry and the foundation may be destroyed. This mechanism is called "roofing". When seepage water is permitted to escape at a gradient which will remove soil, backward erosion starts. Earth dams are made self-healing in this respect by protective filters which permit the water to escape but retain the soil. As long as no soil is lost, no threat to stability exists.

Location: Between the core and the base, the dental work, grouting, and the key wall which is made up of the grout cap plus the seepage wall has this as one of its main functions: to prevent loss of soil due to a minor crack or path in the foundation which might not be detected during construction.

Between the east bank and the downstream pervious embankment the seepage in the east bank will follow the dip in the rock. The material called for in the embankment has a grading which will allow the water to pass safely but will not allow soil grains to be washed through.

Between the east bank and the rock toe a layer of gravel bedding of the grading specified performs the same function.

In conclusion: (To the sluicing item) With normal care in the inspection of the grouting, placing of the various types of fill, it is believed by me that in the area of the dam, the danger due to piping is low.

Very truly yours,

/s/ Karl N. Hendrickson
Foundation Engineer

ERDONK & LATHROP
ULTING ENGINEERS
ONBURY, CONN.

September 5, 1963

T. J. Murphy, Jr., Commissioner
Public Works Department
State Office Building
Hartford, Connecticut

Re: Construction of Dam
Crystal Lake
Middletown, Connecticut
Project BI-BB-53

Attention: S. W. Allen, Chief Engineer

Dear Mr. Allen:

1. In view of the many discussions concerning the design of this project and due to the absence of Professor Hendrickson who is still in Colorado investigating dam sites for Stone and Webster, we have now retained Clarence Welti, P. E., Soils Engineer, to make an additional review of the plans and specifications for the proposed dam at Crystal Lake. Mr. Welti has just returned from Switzerland where he has spent a year studying the latest methods of dam design.

2. Mr. Welti has re-checked the design of the dam for stability and for "piping". His report makes several suggestions for tighter construction controls and for additional safety features which we would like to incorporate into the final plans and specifications. The more important items are as follows:
   a. Reduce core size to 10 foot width at top with side slopes of 1/2:1.
   b. Place core material under piezometric controls.
   c. Construct concrete core wall 8 feet below rock surface and 3 feet into core. Pressure grout to 8 feet below core wall.
   d. Install relief-wells of 3" minimum diameter to depth of 30 feet. The relief-wells should be spaced 8 feet on center and located under the middle of the drainage blanket.

3. We trust that with these additional safety features, the dam design will meet the approval of the Water Resources Commission so that the final contract documents can be completed. We shall be glad to discuss any further questions concerning this dam at your convenience.

Very truly yours,

A. B. Onderdonk P.E.

A. B. Onderdonk, P. E.

cc. Water Resources
A. J. Macchi, P. E.
File

STATE WATER RESOURCES COMMISSION
RECEIVED
NOV 8 1963
ANSWERED..........
REFERRED..........
FILED..........

RECEIVED
OCT 30 1963
ONDERDONK & LATHROP
CONSULTING ENGINEERS
GLASTONBURY, CONN.

CLARENCE W. WELTI, P. E.
C. BRUNO PRIMUS, P. E.

NGINEERING SERVICES INCORPORATED

GLASTONBURY, CONN.
ME-3-4623

October 29, 1963

iderdonk & Lathrop, Engineers
i12 Main Street
.astonbury, Conn.

:: Crystal Lake Dam; Middletown/and Letter A. J. Macchi to
Water Resources Commission on Subject Dam

ENG. OCT 31 1963

ar Sirs:

.th regard to the above I have reviewed the proposed dam and find the llowing:

As regards gradation of core I recommended a reduction in the lower limit of grain size for the following reasons (a) the lower as originally proposed would permit use of varved clays, which would have extremely low strength characteristics and would carry high pore water pressures for long periods of time and (b) there would be inherent difficulty in compacting the materials with high clay percentages.

The core as proposed represents a compromise common to all properly designed dams, i.e., a balance between strength characteristics (including reduction in pore water pressures) and a reasonable permeability in the core. The latter we are obtaining by requiring the silt-clay in somewhat lesser quantities than originally planned but with material wherein the required degree of compaction is readily obtainable. It might be mentioned here that permeability is an inverse square function of the density of the soil and an exponential function of the 10% size. Thus the criteria as mentioned above appear to be adequate.

As concerns providing protection against "sluicing"; action is possibly warranted. However, consideration should be given to the statistical probability of a sluicing action on the downstream portion of the dam. Conditions for a statistical analysis are as follows: (1) the stratification is 20 - 30° to the east (2) the rock exhibits layers in the upper portions, which are somewhat decomposed, but below 10 - 15 feet tends to be fairly tight (3) the usual continuity of blocking or cleaving is perpendicular to the bedding and is never over 3 to 4 feet (4) the depth of the curtain wall and grout is at least 16 feet.

stly, the existance of a continuous stratum sloping from the surface ard the bottom of the grout curtain or below the grout curtain (in all es parallel to prevailing to stratification is statistically about 1 50 at the highest stratum (bottom of grout curtain) with progressively s chance in the deeper strata of such a pervious stratum.

uming that the decomposed stratum or pervious stratum exists immediately the level of bottom of grout curtain; then in order to seep up into the it must find either continuous cleaving (always perpendicular to bed- g) or it must find further pervious layers combined with cleavage. The ter seems far more likely. In this consideration the liklihood of per- us strata or voids parallel to bedding place is perhaps in the magnitude 1 in 50 to 1 in 10. However, the likelihood of connecting cleaving is tainly far greater, possibly 1 to 100. ?

ce the likelihood of any "sluicing" would be 1/50 x 1/30 x 1/100 = ± 1 150,000. Admittedly the probability is approximate but it certainly ces the chance of "sluicing" in the proper light. Furthermore the chances "sluicing" into the core are less than the above; since here the closest sible point of "sluicing" would be about 10 feet from the grout curtain the chances of such be about 1 to infinity with a gradual drop-off to above odds.

uming that such "sluicing" were to take place the question arises where- could material be removed? The tremendous shell would act as a weighted ter and the excessive water would be recaptured at the downstream stone nket. This stone blanket should, however, be carried to within 8 feet the core.

the agency insists in protection against the "sluicing" I would insist t the scheme used be that in B-a of Mr. Macchi's letter since that B-b ld seriously effect the stability and the permeability characteristics the dam.

y truly yours,

INEERING SERVICES, INC.

Clarence W. Welti, P. E.

CWW:m
cc:file

J. MACCHI • ENGINEERS

GIULIO PIZZETTI ASSOCIATE CONSULTANT

LLETT STREET HARTFORD, CONN. PHONE 525-6631
IRSO DUCA ABRUZZI TORINO, ITALY PHONE 519-473

E. A.S.C.E. A.C.I.

November 27, 1963

State of Connecticut
Water Resources Commission
State Office Building
165 Capitol Avenue
Hartford 15, Connecticut

STATE WATER RESOURCES
COMMISSION
RECEIVED
NOV 29 1963
ANSWERED
REFERRED
FILED

Attention Mr. William P. Sander

Re: Crystal Lake Dam
Middletown, Conn.

Dear Mr. Sander:

I have reviewed the letter from Clarence W. Welti dated October 29, 1963 regarding the above-referenced dam. Following are my comments:

In regard to gradation of the core, there may be a misunderstanding. There should be no disagreement on this point. The gradation chart furnished us shows "lower limit" which establishes the largest sizes that can be used in the core. This chart indicates that a core material with a minimum size close to fine sand (0.065) m.m.) can be used. A material close to this minimum size would have no binder and would be pervious making a poor core. A minimum of 5% clay should be included. This means revising the bottom of "lower limit" curve slightly to include a minimum of approximately 5% clay. I am sure this was the intent in the design of the core.

In regard to protection against slucing action, it is my considered opinion that this point should not be analysed using statistical probability so long as there are avenues of design that avoid this uncertainty; especially considering unexplained failure of the previous dam.

State of Connecticut
Water Resources Commission
Hartford 15, Connecticut

November 27, 1963

Retaining the proposed design it appears the simplest solution is to reduce the core eliminating that part downstream of the cut off wall which is vulnerable.

Very truly yours,

A. J. MACCHI, ENGINEERS

A. J. MACCHI

cc.

ENG. DEC 11 1963

ONDERDONK & LATHROP
CONSULTING ENGINEERS
2512 MAIN STREET
GLASTONBURY, CONNECTICUT

RUCE ONDERDONK, P.E.
IRT P. LATHROP, P.E.

TELEPHONE 633-9409

December 10, 1963

Mr. T. J. Murphy, Jr., Commissioner
Public Works Department
State Office Building
Hartford 15, Connecticut

Re: Construction of Dam
Crystal Lake, Middletown
Project BI-BB-53

Attention: Mr. M. R. Case,
Assistant Chief Engineer

Dear Mr. Case:

In reply to Mr. Macchi's letter of November 27, 1963, which you forwarded to us on December 5, 1963, we make the following comments:

1. With reference to gradation of the core, we accept this suggestion and will modify the core gradation curve accordingly.
2. In reply to protection against "sluicing action", we have again conferred with Mr. Welti, our soils consultant, who states, "The analysis of the dam was not done by statistical probability; rather the statistical probability was used to place the problem of 'sluicing' in its proper light. As mentioned in my letter of October 20, 1963, in the next to the last paragraph, the 'sluicing' that might occur, could not cause damage of any substance to the dam. Its head could not conceivably be more than a few feet above the hydrostatic head within the dam at the point of entry into the core. Furthermore, the shell is designed as a filter adjacent to the core and would not permit core material to filter through to the stone blanket".

If there are any further questions please contact this office.

Yours very truly,

A. B. Onderdonk

A. Bruce Onderdonk, P. E.

ABO/c

STATE OF CONNECTICUT

WATER RESOURCES COMMISSION

STATE OFFICE BUILDING · HARTFORD 15, CONNECTICUT

CERTIFICATE OF APPROVAL

April 27, 1966

State Board of Fisheries & Game
State Office Building
Hartford, Connecticut

TOWN: Middletown
RIVER: Summer Brook
TRIBUTARY: Prout Brook
CODE NO.: C27.5 SB2.3 PB0.7

Gentlemen:

NAME AND LOCATION OF STRUCTURE: Crystal Lake Dam on Prout Brook in the Town of Middletown.

DESCRIPTION OF STRUCTURE AND WORK PERFORMED: Construction of earth dam about 115 feet long and about 35 feet high

CONSTRUCTION PERMIT ISSUED UNDER DATE OF: March 24, 1964

This certifies that the work and construction included in the plans submitted, for the structure described above, has been completed to the satisfaction of this Commission and that this structure is hereby approved in accordance with Section 25-114 of the 1958 Revision of the General Statutes.

The owner is required by law to record this Certificate in the land records of the town or towns in which the structure is located.

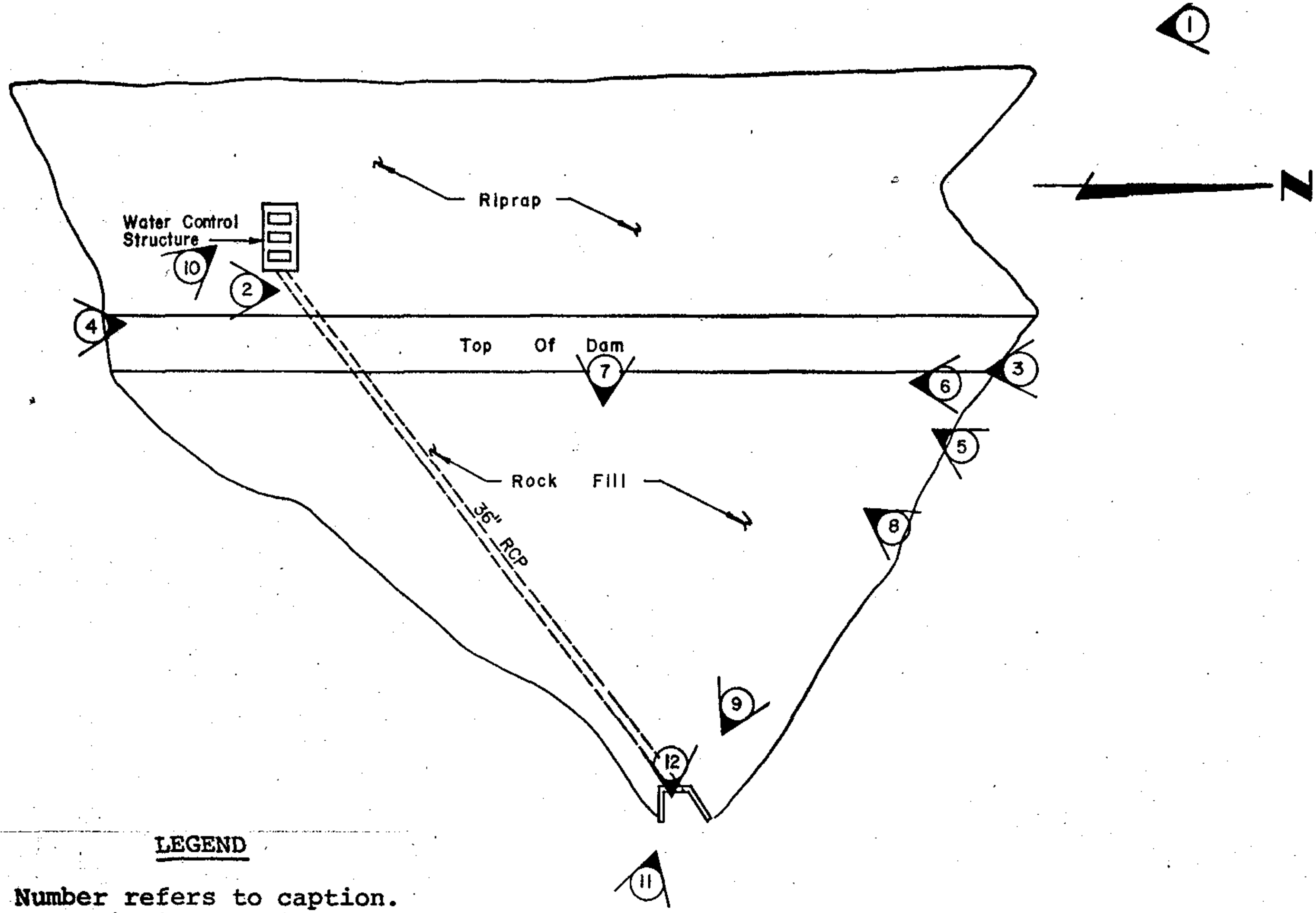
WATER RESOURCES COMMISSION

BY:____________________
William S. Wise, Director

WSW:js

APPENDIX C

PHOTOGRAPHS



LEGEND

Number refers to caption. Arrow indicates direction of photograph.

CRYSTAL LAKE DAM

PHOTO LOCATION MAP

PHOTO #1: Upstream face of dam.

PHOTO #2: Upstream face of dam. Note sappling trees growing through riprap.

PHOTO #3: Crest of dam from left (North) abutment.

PHOTO #4: Crest of dam from right (South) abutment.

PHOTO #5: Crest of dam and rockfill on downstream slope from left abutment.

PHOTO #6: Rockfill on downstream slope of dam.

PHOTO #7: Looking downstream from crest. Trees growing out of rockfill up to 4 inches in diameter.

PHOTO #8: Downstream face of dam (looking upslope).

PHOTO #9: Looking toward outlet structure near toe of dam. Note tree uprooted on the slope.

PHOTO #10: Water control structure.

PHOTO #11: 36"-diameter outlet pipe and grated endwall.

PHOTO #12: Looking downstream along outlet channel. Note large trees and brush.

PHOTO #13: Reservoir Area. Dam is at lower right of photograph.

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

DETERMINATION OF SPILLWAY TEST FLOOD*

A. SIZE CLASSIFICATION

Storage Volume (Ac.-Ft.) 350

Height of Dam (Ft.) 50

Size Classification INTERMEDIATE

B. HAZARD POTENTIAL CLASSIFICATION

Category	Loss of Life	Economic Loss
Low	None expected	Minimal
Significant	Few	Appreciable
High	More than few	Excessive

Hazard Classification HIGH

C. HYDROLOGIC EVALUATION GUIDELINES

Hazard	Size	Spillway Design Flood
Low	Small	50 to 100-Year Frequency
	Intermediate	100-Year Frequency to 1/2 PMF
	Large	1/2 PMF to PMF
Significant	Small	100-Year Frequency to 1/2 PMF
	Intermediate	1/2 PMF to PMF
	Large	PMF
High	Small	1/2 PMF to PMF
	Intermediate	PMF
	Large	PMF

Spillway Test Flood PMF

*Based upon "Recommended Guidelines for Safety Inspection of Dams" Department of the Army, Office of the Chief of Engineers, November 1976.

SPILLWAY TEST FLOOD (PMF)

RAINFALL

PMP = 24 FOR 6 HOUR DURATION (DESIGN OF SMALL DAMS - FIG. 15)

RECOMMENDED REDUCTION FACTOR = 20%

PMP_{6HRS} = 24 x .80 = 19.2 IN.

PMP FOR 1 HOUR DURATION = .5(19.2) = 9.6 IN.
(FIG. 18)

PMP FOR 24 HOUR DURATION = 1.20 x 19.2 = 23.04 IN.
(FIG. 16)

RUNOFF

WATERSHED IS SPARSELY DEVELOPED & COMPOSED OF GLACIAL TILL SOILS. ASSUME SOIL IS PARTIALLY SATURATED
SCS CN VALUE = 80

FROM FIGURE A-4

1 HR RAINFALL = 9.6 ∴ RUNOFF 7.1 IN

6 HR RAINFALL = 19.6 ∴ RUNOFF 16.5 IN

24 HR RAINFALL = 23.04 ∴ RUNOFF 20.0 IN

PROBABLE MAXIMUM FLOOD

$$Q = \frac{484\,AR}{T_p}$$

A = area (sq. mi) ∴ 0.26 mi²

R = runoff , L = 1800'
S = 0.09 %

$$T_c = \frac{.00013\,L^{0.77}}{.0944^{0.385}} = 0.1 \text{ HRS}$$

$$T_p = D/2 + .6(T_c)$$

Q 1 HOUR

$$T_p = 1/2 + 0.6(.1) = .56 \text{ HRS}$$

$$Q_{1HR} = \frac{484 \times .26 \times 7.1}{.56} = 1595 \text{ cfs}$$

Q 6 HOUR

$$T_p = 6/2 + 0.6(.1) = 3.06$$

$$Q_{6HR} = \frac{484 \times .26 \times 16.5}{3.06} = 679 \text{ cfs}$$

Q 24 HOURS

$$T_p = 24/2 + .6(.1) = 12.06$$

$$Q_{24HR} = \frac{484 \times .26 \times 20.0}{12.06} = 209 \text{ cfs}$$

VOL. OF RUNOFF 1 HOUR STORM

$$\frac{7.1 \text{ IN}}{12 \text{ IN/FT}} \times .26 \text{ mi}^2 \times 640 \text{ AC/mi}^2 = 98 \text{ ACRE-FEET}$$

VOL. OF RUNOFF 6 HOUR STORM

$$\frac{16.5 \text{ IN}}{12 \text{ IN/FT}} \times .26 \text{ mi}^2 \times 640 \text{ AC/mi}^2 = 229 \text{ ACRE-FEET}$$

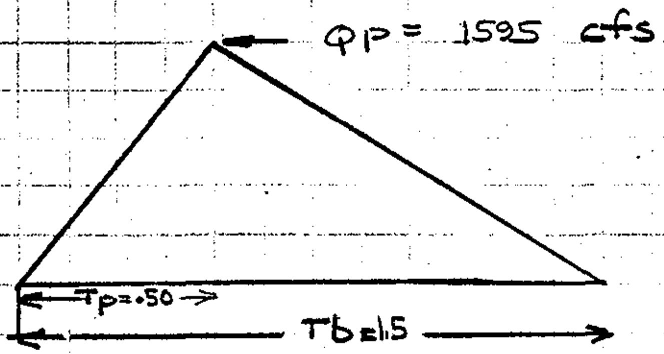
VOL. OF RUNOFF 24 HOUR STORM

$$\frac{20.0 \text{ IN}}{12 \text{ IN/FT}} \times .26 \text{ mi}^2 \times 640 \text{ AC/mi}^2 = 277 \text{ ACRE-FEET}$$

<u>HYDROGRAPHS</u>

A TRIANGULAR HYDROGRAPH IS TO BE USED FOR THE ROUTING OF THE TEST FLOODS THROUGH THE RESERVOIR. A ROUTING WILL BE DONE FOR THE 1 HOUR, 6 HOUR, AND 24 HOUR DURATION PMP TO DETERMINE THE CONTROLING STORM. THE DURATION OF RUNOFF (Tb) WILL BE SET SO THAT THE VOLUME OF THE HYDROGRAPH EQUALS THE PREVIOUSLY DETERMINED VOLUME OF RUNOFF

HYDROGRAPH 1 HOUR PMF



VOL = 1/2 Qp Tb

$$\frac{90 \text{ ACRE FEET}}{.5 \times 1461 \text{ CF/SEC}} = Tb$$

$$\frac{98 \text{ ACRE-FT} \times 43560 \text{ AC-FT}}{.5 \times 1595 \text{ CF/SEC} \times 3600 \frac{\text{SEC}}{\text{HR}}} = 1.48$$ SAY Tb = 1.5 hours

SET Tp = 1/3 Tb

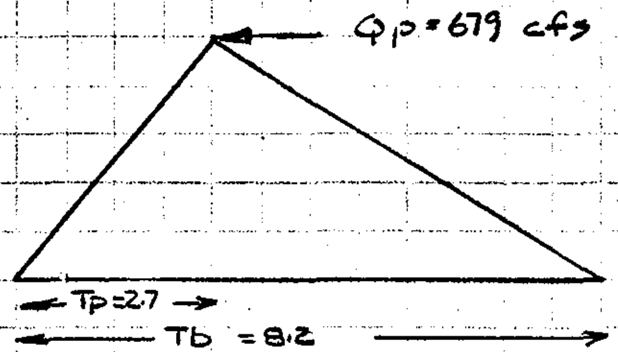
Tp = .50 HOURS

TABULAR HYDROGRAPH (PMF)

HOURS	Q (cfs)
0.0	0
0.10	319
0.20	638
0.30	957
0.40	1276
0.50	1595
0.60	1436
0.70	1276
0.80	1117
0.90	957
1.0	797

HOURS	Q
1.1	638
1.2	478
1.3	319
1.4	159
1.5	0

HYDROGRAPH 6 HOUR PMF



$VOL = \frac{1}{2} Q_p T_b$

$\frac{229 \text{ ACRE-FT}}{.5 \times 679 \text{ CFS}} = T_b$

$\frac{229 \text{ ACRE-FT} \times 43560 \text{ FT}^3/\text{ACRE}}{.5 \times 679 \text{ CF/sec} \times 3600 \text{ sec/HR}} = T_b = 8.2 \text{ hours}$

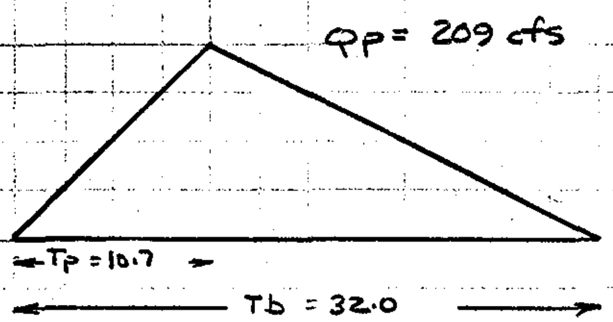
SET $T_p = \frac{1}{3} T_b$

$= 2.7$ hrs

TABULAR HYDROGRAPH

HOURS	PMF Q (cfs)	1/2 PMF Q (cfs)
0.0	0	0
1.0	251	125
2.0	503	252
2.7	679	340
3.0	642	321
4.0	519	260
5.0	395	198
6.0	272	136
7.0	148	74
8.2	0	0

HYDROGRAPH FOR 24 HOUR PMF



VOL = 1/2 Qp Tb

$$\frac{277 \text{ ACRE-FT}}{.5 \times 209 \text{ CFS}} = Tb$$

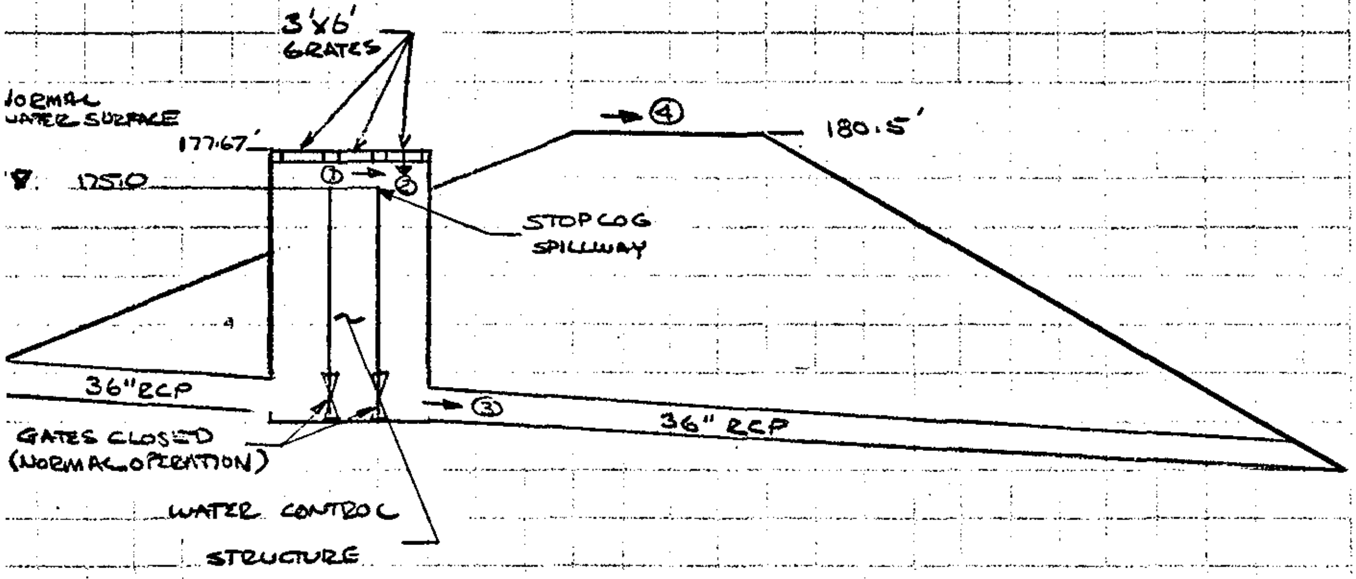
$$\frac{277 \text{ ACRE-FT} \times 43560 \text{ FT}^2/\text{ACRE}}{.5 \times 209 \times 3600 \text{ SEC/HR}} = 32 = Tb$$

SET Tp = 1/3 Tb = 10.7

TABULAR HYDROGRAPH

HOURS	Q cfs
0	0
3	59
6	117
9	176
10.7	209
12	196
15	167
18	137
21	108
24	78
27	49
30	20
32	0

STAGE DISCHARGE DATA



DISCHARGE ANALYSIS

THERE ARE SEVERAL DIFFERENT MEANS IN WHICH WATER CAN POTENTIALLY DISCHARGE THROUGH OR OVER THE DAM STRUCTURE AS SUMMARIZED BELOW.

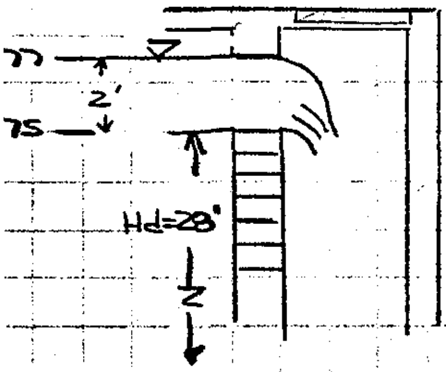
1. WATER PASSING OVER THE STOP LOG SPILLWAY AND THROUGH THE OUTLET CONDUIT. THIS DISCHARGE IS A SPILLWAY CONDITION FROM ELEV. 175 TO 176. ABOVE ELEVATION 176 THE DISCHARGE IS AN ORIFACE CONDITION.

2. ABOVE ELEVATION 177.67, WATER ENTERS THROUGH THE RIGHT GATE ONLY, FUNCTIONING AS A DROP INLET.

3. THE ABOVE DESCRIBED FLOW DISCHARGES ARE POTENTIALLY CONTROLLED BY THE 36" RCP OUTLET CONDUIT, WHICH FUNCTIONS AS AN ORIFACE DUE TO ITS STEEP SLOPE.

4. A RISE IN THE WATER SURFACE LEVEL ABOVE ELEVATION 180.5, CAUSE WATER TO OVER TOP THE DAM, IN ADDITION TO STILL DISCHARGING THROUGH THE CONDUIT

STOPLOG SPILLWAY / ORIFACE



$$Q = CLH^{3/2}$$

SPILLWAY LENGTH = 6'

FROM LINSLEY AND FRANZINI "WATER RESOURCES ENG." TABLE 10.3

$$H_d/h = 28/2 = 14 \therefore C = 3.29$$

	STAGE (ELEV)	DISCHARGE (Q)
	175.0	0
spillway	176.0	19.7
	177.0	55.8
	178.0	82
	179.0	100
orifice	180.5	122
	181.0	129
	182.0	141

ABOVE ELEV. 177.0', OPENING IS SUBMERGED AND ACTS AS AN ORIFICE

$$Q = C_d A \sqrt{2gh}$$

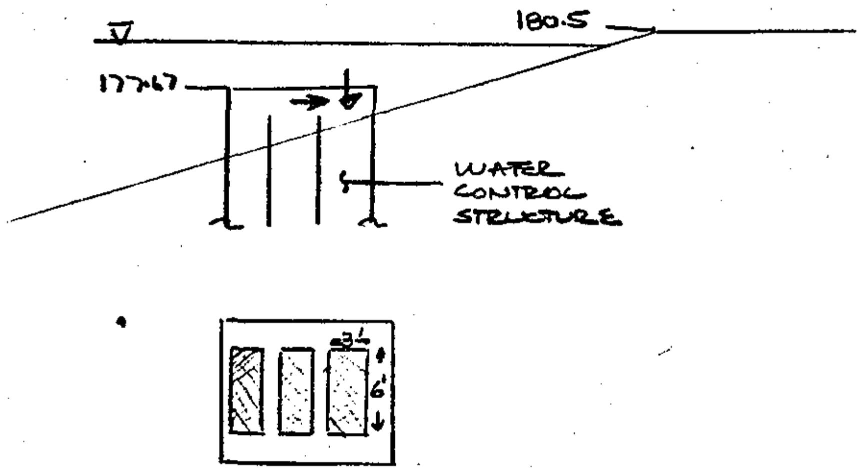
WHERE:

$C_d = 0.60$

$A = 6 \times 2 = 12$ sf.

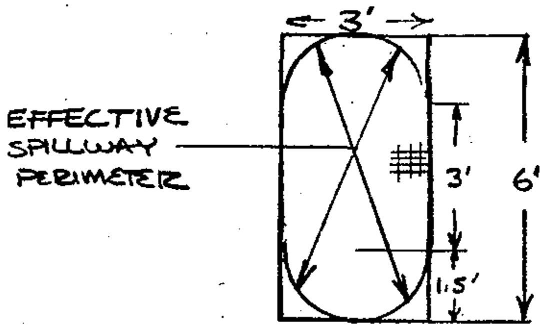
h IS MEASURED TO CENTER OF ORIFICE (ELEV. 176.0)

DROP INLET



THIS GRATE FUNCTIONS AS DROP INLET FOR WATER LEVELS GREATER THAN 177.67. THE OTHER GATES DO NOT FUNCTION AS OUTET DISCHARGES, THEY ARE RESTRICTED TO CAPACITY OF STOPLOG SPILLWAY ACTING AS AN ORIFICE.

GRATE DETAIL



EFFECTIVE SPILLWAY PERIMETER

$- 3' + 3' = 6'$

$- \frac{1}{2}\pi(3)(2) = 9.42'$

TOTAL = 15.42'

EFFECTIVE AREA

$+ 3 \times 3 = 9$ SF

$+ \frac{\pi(3)^2}{4} = 7.1$ SF

TOTAL = 16.1 SF

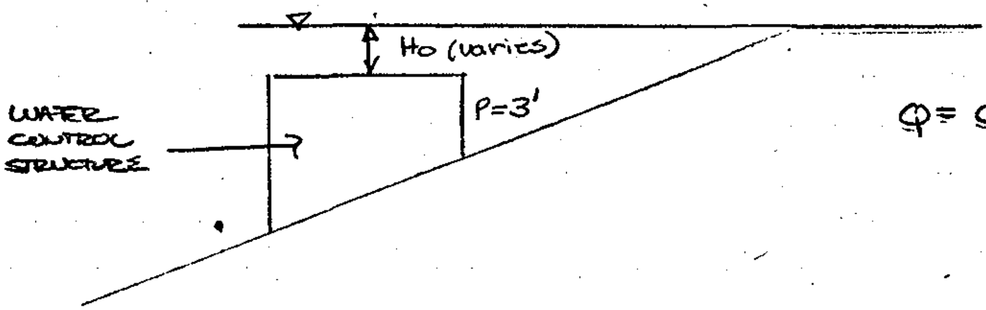
EQUIVILENT RADIUS

$\pi r^2 = 16.1$ SF

$r = \sqrt{\frac{16.1}{\pi}}$

$r = 2.26'$

USING DROP INLET PROCEDURE
(DESIGN OF SMALL DAMS)



$$Q = CLH^{3/2}$$

$$P/R = 3'/2.26' = 1.33$$

ELEV.	Ho	Ho/Rs	C (FIG. 283)	CALC.	Q (cfs)
177.67	0				0
178.0	0.33	.33/2.26 = .15	3.8	$3.8(15.42)(.33)^{3/2}$	11.1
179.0	1.33	1.33/2.26 = .59	3.1	$3.1(15.42)(1.33)^{3/2}$	73.3
180.5	2.83	2.83/2.26 = 1.25	1.65	$1.65(15.42)(2.83)^{3/2}$	121
181.0	3.33	3.33/2.26 = 1.47	1.40	$1.40(15.42)(3.33)^{3/2}$	131
182.0	4.33	4.33/2.26 = 1.92	1.08	$1.08(15.42)(4.33)^{3/2}$	150

OUTLET PIPE – 36" RCP

ALL FLOW THAT ENTER WATER CONTROL STRUCTURE THROUGH STOP LOG SPILLWAY OR DROP INLET MUST PASS THROUGH DAM VIA 36" RCP. THE CAPACITY OF THIS CONDUIT MUST BE COMPUTED TO DETERMINE CONTROL.

CONDUIT IS STEEP SLOPE THEREFORE INLET-ORIFICE CONTROL

$$Q = C_d A \sqrt{2gh}$$

$C_d = 0.6$

$A = \frac{\pi (3)^2}{4} = 7.07$ s.f.

INV. of 36" RCP = 147'

STAGE	HEAD	Q (cfs)
175.	28	180
176.	29	183
177.	30	186
178	31	189
179	32	192
180.5	33.5	196
181	34	198
182	35	201

EMBANKMENT OVERTOPPING

LENGTH = 130
C = 3.0 (Broad crest weir)

$Q = CLH^{3/2}$

STAGE	HEAD	Q
181	0.5	137
182	1.5	716

COMPOSITE STAGE DISCHARGE

STAGE	Q SPILLWAY/ ORIFICE	Q DROP INLET	Q PIPE (36") (capacity)	Q EMB. OVERTOP	Q CONTROLS (cfs)
175	0	0	180	0	0
176	19.7	0	183	0	19.7
177	55.8	0	186	0	55.8
178	82	11.1	189	0	93.1
179	100	73.3	192	0	173.3
180.5	122	121	196	0	196.0
181	129	131	198	137	335.0
182	141	150	201	716	917.0

CRYSTAL LAKE 1 HR STM FLOOD ROUTING JGM 12/19/79

INPUT DATA: STAGE / DISCHARGE

S=175.00FT Q= 0CFS S=176.00FT Q= 19CFS S=177.00FT Q= 55CFS S=178.00FT Q= 93CFS
S=179.00FT Q= 173CFS S=180.50FT Q= 196CFS S=181.00FT Q= 335CFS S=182.00FT Q= 917CFS
S=190.00FT Q= 2,000CFS
IE=175.0 IV= 0.0 E=175.0 A= 30.80 E=190.0 A= 55.00

HOUR	INFLOW	MASS INFLOW	WATER EL.	TAIL WATER	OUTFLOW	MASS OUTFLOW	STORAGE(R)	STORAGE(A)
0.00	0CFS	0.00AC-F	175.00FT	.00FT	0CFS	0.00AC-F	0.00AC-F	0.00AC-F
0.10	319CFS	1.31AC-F	175.04FT	0.00FT	0CFS	0.00AC-F	1.31AC-F	1.31AC-F
0.20	638CFS	5.27AC-F	175.16FT	0.00FT	3CFS	0.02AC-F	5.25AC-F	5.25AC-F
0.30	957CFS	11.86AC-F	175.37FT	0.00FT	7CFS	0.06AC-F	11.80AC-F	11.80AC-F
0.40	1,276CFS	21.09AC-F	175.66FT	0.00FT	12CFS	0.14AC-F	20.94AC-F	20.94AC-F
0.50	1,595CFS	32.95AC-F	176.03FT	0.00FT	20CFS	0.28AC-F	32.67AC-F	32.67AC-F
0.60	1,436CFS	45.47AC-F	176.40FT	0.00FT	33CFS	0.50AC-F	44.97AC-F	44.97AC-F
0.70	1,276CFS	56.68AC-F	176.73FT	0.00FT	45CFS	0.83AC-F	55.85AC-F	55.85AC-F
0.80	1,117CFS	66.57AC-F	177.01FT	0.00FT	55CFS	1.24AC-F	65.32AC-F	65.32AC-F
0.90	957CFS	75.14AC-F	177.25FT	0.00FT	64CFS	1.74AC-F	73.40AC-F	73.39AC-F
1.00	797CFS	82.39AC-F	177.44FT	0.00FT	71CFS	2.30AC-F	80.08AC-F	80.08AC-F
1.10	638CFS	88.32AC-F	177.59FT	0.00FT	77CFS	2.92AC-F	85.39AC-F	85.39AC-F
1.20	478CFS	92.93AC-F	177.70FT	0.00FT	81CFS	3.58AC-F	89.34AC-F	89.34AC-F
1.30	319CFS	96.22AC-F	177.78FT	0.00FT	84CFS	4.27AC-F	91.95AC-F	91.95AC-F
1.40	159CFS	98.20AC-F	177.81FT	0.00FT	86CFS	4.98AC-F	93.22AC-F	93.22AC-F
1.50	0CFS	98.85AC-F	177.81FT	0.00FT	86CFS	5.69AC-F	93.16AC-F	93.16AC-F
2.00	0CFS	98.85AC-F	177.71FT	0.00FT	82CFS	9.16AC-F	89.68AC-F	89.69AC-F
5.00	0CFS	98.85AC-F	177.20FT	0.00FT	62CFS	27.14AC-F	71.71AC-F	71.71AC-F
10.00	0CFS	98.85AC-F	176.57FT	0.00FT	39CFS	48.29AC-F	50.55AC-F	50.55AC-F
20.00	0CFS	98.85AC-F	175.86FT	0.00FT	16CFS	71.53AC-F	27.32AC-F	27.32AC-F

CRYSTAL LAKE DAM MDLT 6 HR HYD 79-90-10 FLOOD ROUTING DKS 12/06/79

INPUT DATA: STAGE / DISCHARGE

S=175.00FT Q= 0CFS S=176.00FT Q= 19CFS S=177.00FT Q= 55CFS S=178.00FT Q= 93CFS
S=179.00FT Q= 173CFS S=180.50FT Q= 196CFS S=181.00FT Q= 335CFS S=182.00FT Q= 917CFS
S=190.00FT Q= 2,000CFS
IE=175.0 IV= 0.0 E=175.0 A= 30.80 E=190.0 A= 55.00

HOUR	INFLOW	MASS INFLOW	WATER EL.	TAIL WATER	OUTFLOW	MASS OUTFLOW	STORAGE(R)	STORAGE(A)
0.00	0CFS	0.00AC-F	175.00FT	.00FT	0CFS	0.00AC-F	0.00AC-F	0.00AC-F
1.00	251CFS	10.37AC-F	175.32FT	0.00FT	6CFS	0.26AC-F	10.10AC-F	10.10AC-F
2.00	503CFS	41.52AC-F	176.25FT	0.00FT	28CFS	1.71AC-F	39.81AC-F	39.80AC-F
2.70	679CFS	75.71AC-F	177.19FT	0.00FT	62CFS	4.37AC-F	71.34AC-F	71.34AC-F
3.00	642CFS	92.09AC-F	177.61FT	0.00FT	78CFS	6.12AC-F	85.96AC-F	85.96AC-F
4.00	519CFS	140.07AC-F	178.68FT	0.00FT	148CFS	15.50AC-F	124.56AC-F	124.56AC-F
5.00	395CFS	177.83AC-F	179.33FT	0.00FT	178CFS	29.00AC-F	148.83AC-F	148.83AC-F
6.00	272CFS	205.40AC-F	179.67FT	0.00FT	183CFS	43.95AC-F	161.44AC-F	161.44AC-F
7.00	148CFS	222.75AC-F	179.72FT	0.00FT	184CFS	59.15AC-F	163.60AC-F	163.60AC-F
8.20	0CFS	230.09AC-F	179.44FT	0.00FT	180CFS	77.22AC-F	152.87AC-F	152.87AC-F
10.00	0CFS	230.09AC-F	178.77FT	0.00FT	155CFS	102.18AC-F	127.91AC-F	127.91AC-F
15.00	0CFS	230.09AC-F	177.46FT	0.00FT	72CFS	149.40AC-F	80.68AC-F	80.68AC-F
20.00	0CFS	230.09AC-F	176.73FT	0.00FT	46CFS	174.07AC-F	56.01AC-F	56.01AC-F
30.00	0CFS	230.09AC-F	175.92FT	0.00FT	18CFS	200.80AC-F	29.28AC-F	29.28AC-F
40.00	0CFS	230.09AC-F	175.55FT	0.00FT	10CFS	212.85AC-F	17.23AC-F	17.23AC-F
50.00	0CFS	230.09AC-F	175.32FT	0.00FT	6CFS	219.99AC-F	10.10AC-F	10.10AC-F

CRYSTAL LAKE DAM MDLT 24 HR HYD 79-90-10 FLOOD ROUTING DKS 12/06/79

INPUT DATA: STAGE / DISCHARGE

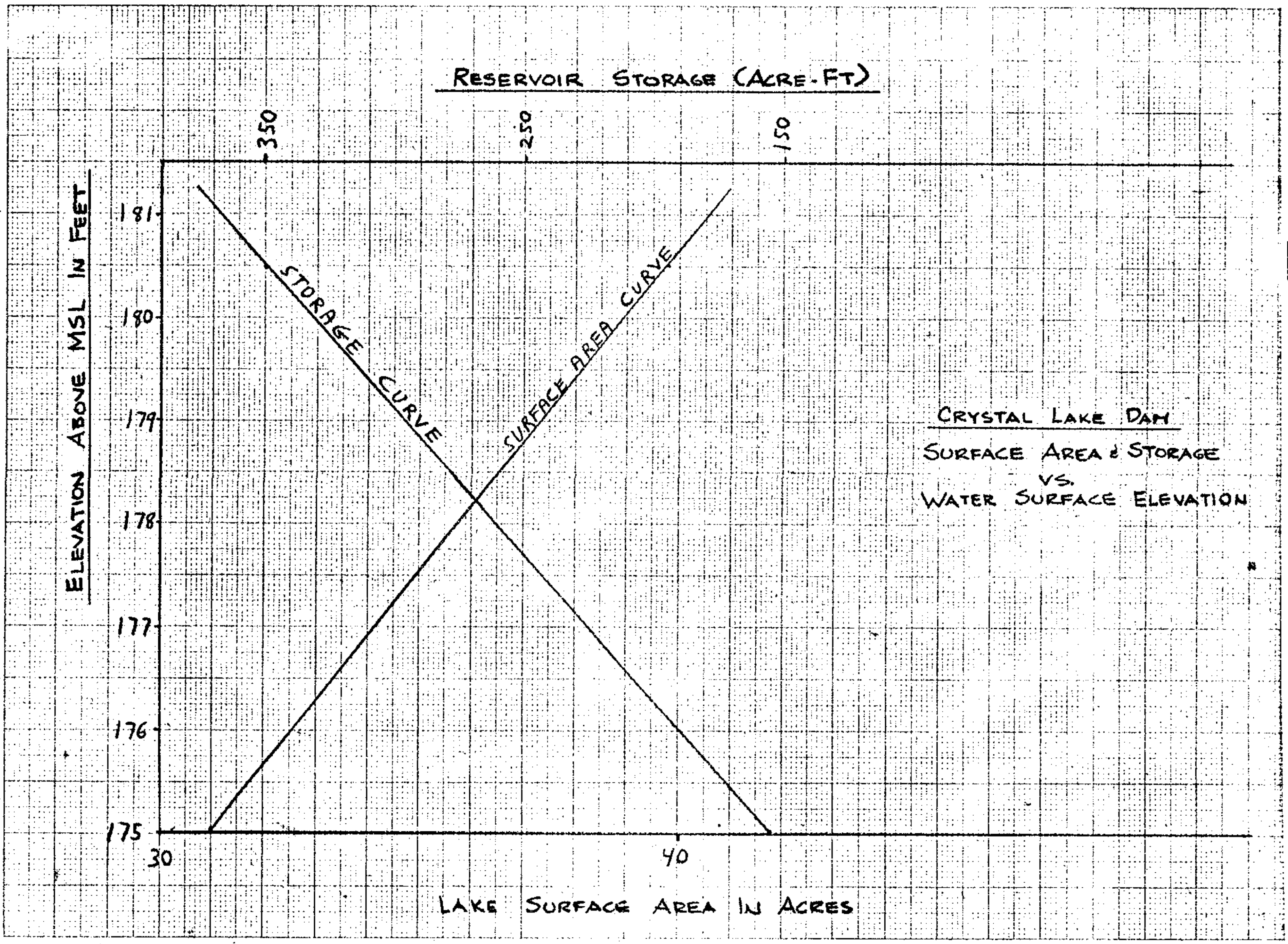
S=175.00FT Q= 0CFS S=176.00FT Q= 19CFS S=177.00FT Q= 55CFS S=178.00FT Q= 93CFS
S=179.00FT Q= 173CFS S=180.50FT Q= 196CFS S=181.00FT Q= 335CFS S=182.00FT Q= 917CFS
S=190.00FT Q= 2,000CFS
IE=175.0 IV= 0.0 E=175.0 A= 30.80 E=190.0 A= 55.00

HOUR	INFLOW	MASS INFLOW	WATER EL.	TAIL WATER	OUTFLOW	MASS OUTFLOW	STORAGE(R)	STORAGE(A)
0.00	0CFS	0.00AC-F	175.00FT	.00FT	0CFS	0.00AC-F	0.00AC-F	0.00AC-F
3.00	59CFS	7.31AC-F	175.21FT	0.00FT	4CFS	0.53AC-F	6.77AC-F	6.78AC-F
6.00	117CFS	29.13AC-F	175.82FT	0.00FT	16CFS	3.09AC-F	26.04AC-F	26.04AC-F
9.00	176CFS	65.45AC-F	176.70FT	0.00FT	45CFS	10.69AC-F	54.75AC-F	54.75AC-F
10.70	209CFS	92.49AC-F	177.26FT	0.00FT	65CFS	18.48AC-F	74.01AC-F	74.01AC-F
12.00	196CFS	114.25AC-F	177.66FT	0.00FT	80CFS	26.35AC-F	87.90AC-F	87.90AC-F
15.00	167CFS	159.25AC-F	178.25FT	0.00FT	113CFS	50.43AC-F	108.81AC-F	108.81AC-F
18.00	137CFS	196.94AC-F	178.46FT	0.00FT	130CFS	80.65AC-F	116.28AC-F	116.28AC-F
21.00	108CFS	227.31AC-F	178.42FT	0.00FT	126CFS	112.51AC-F	114.80AC-F	114.80AC-F
24.00	78CFS	250.37AC-F	178.23FT	0.00FT	112CFS	142.15AC-F	108.21AC-F	108.21AC-F
27.00	49CFS	266.11AC-F	177.97FT	0.00FT	92CFS	167.47AC-F	98.63AC-F	98.63AC-F
30.00	20CFS	274.66AC-F	177.61FT	0.00FT	78CFS	188.64AC-F	86.02AC-F	86.02AC-F
32.00	0CFS	276.32AC-F	177.31FT	0.00FT	67CFS	200.72AC-F	75.59AC-F	75.59AC-F
35.00	0CFS	276.32AC-F	176.88FT	0.00FT	51CFS	215.48AC-F	60.83AC-F	60.83AC-F
40.00	0CFS	276.32AC-F	176.36FT	0.00FT	32CFS	232.90AC-F	43.41AC-F	43.41AC-F
50.00	0CFS	276.32AC-F	175.75FT	0.00FT	14CFS	252.58AC-F	23.73AC-F	23.73AC-F
75.00	0CFS	276.32AC-F	175.16FT	0.00FT	3CFS	271.28AC-F	5.04AC-F	5.04AC-F

CRYSTAL LAKE 1/2 PMF 6 HR. HYD. 79-90-10 FLOOD ROUTING DKS 12/14/79

INPUT DATA: STAGE / DISCHARGE
S=175.00FT Q= 0CFS S=176.00FT Q= 19CFS S=177.00FT Q= 55CFS S=178.00FT Q= 93CFS
S=179.00FT Q= 173CFS S=180.50FT Q= 196CFS S=181.00FT Q= 335CFS S=182.00FT Q= 917CFS
S=190.00FT Q= 2,000CFS
IE=175.0 IV= 0.0. E=175.0 A= 30.80 E=190.0 A= 55.00

HOUR	INFLOW	MASS INFLOW	WATER EL.	TAIL WATER	OUTFLOW	MASS OUTFLOW	STORAGE(R)	STORAGE(A)
0.00	0CFS	0.00AC-F	175.00FT	.00FT	0CFS	0.00AC-F	0.00AC-F	0.00AC-F
1.00	125CFS	5.16AC-F	175.16FT	0.00FT	3CFS	0.13AC-F	5.03AC-F	5.03AC-F
2.00	252CFS	20.74AC-F	175.63FT	0.00FT	12CFS	0.78AC-F	19.95AC-F	19.96AC-F
2.70	340CFS	37.86AC-F	176.13FT	0.00FT	24CFS	1.85AC-F	36.00AC-F	36.00AC-F
3.00	321CFS	46.06AC-F	176.36FT	0.00FT	32CFS	2.56AC-F	43.49AC-F	43.49AC-F
4.00	260CFS	70.07AC-F	176.97FT	0.00FT	54CFS	6.19AC-F	63.87AC-F	63.87AC-F
5.00	198CFS	88.99AC-F	177.37FT	0.00FT	69CFS	11.33AC-F	77.65AC-F	77.65AC-F
6.00	136CFS	102.79AC-F	177.59FT	0.00FT	77CFS	17.44AC-F	85.35AC-F	85.35AC-F
7.00	74CFS	111.47AC-F	177.65FT	0.00FT	80CFS	23.98AC-F	87.49AC-F	87.49AC-F
8.20	0CFS	115.14AC-F	177.53FT	0.00FT	75CFS	31.72AC-F	83.41AC-F	83.41AC-F
10.00	0CFS	115.14AC-F	177.23FT	0.00FT	64CFS	42.18AC-F	72.96AC-F	72.96AC-F
15.00	0CFS	115.14AC-F	176.59FT	0.00FT	41CFS	64.03AC-F	51.10AC-F	51.10AC-F
20.00	0CFS	115.14AC-F	176.17FT	0.00FT	25CFS	77.89AC-F	37.25AC-F	37.25AC-F
25.00	0CFS	115.14AC-F	175.89FT	0.00FT	17CFS	86.90AC-F	28.24AC-F	28.24AC-F
30.00	0CFS	115.14AC-F	175.69FT	0.00FT	13CFS	93.37AC-F	21.76AC-F	21.76AC-F

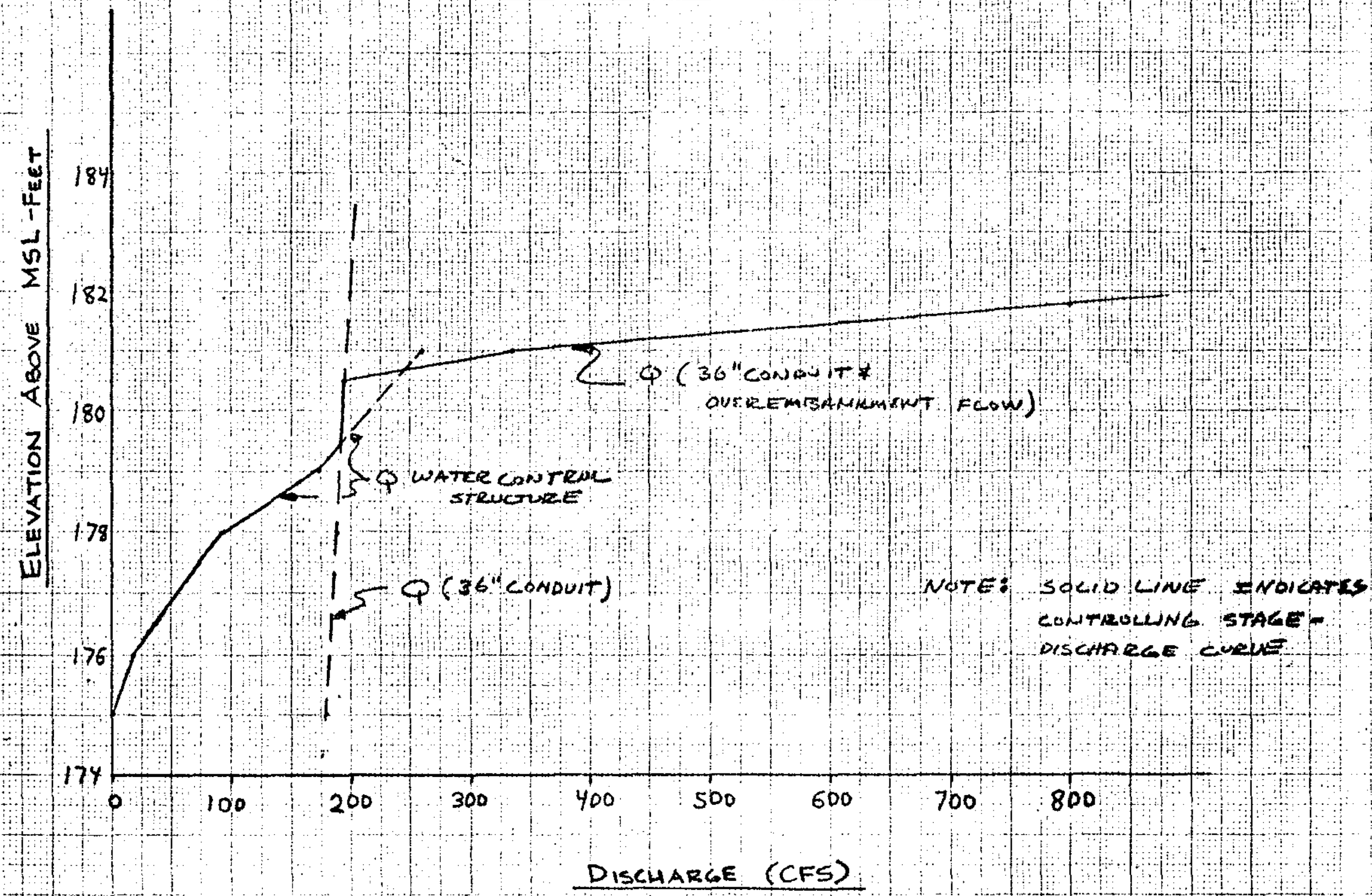


'STAL LAKE DAM

FLAHERTY-GIAVARA ASSOCIATES
ENVIRONMENTAL DESIGN CONSULTANTS
ONE COLUMBUS PLAZA, NEW HAVEN, CONN. 06510/203/789-1260

SHEET NO. 10 OF 29
BY DKS DATE 12/14/79
CHK'D.BY PB DATE 12/14/79

CRYSTAL LAKE DAM
STAGE - DISCHARGE CURVE



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FLAHERTY-GIAVARA ASSOCIATES
ENVIRONMENTAL DESIGN CONSULTANTS
ONE COLUMBUS PLAZA, NEW HAVEN, CONN. 06510/203/789-1260

SHEET NO. 14 OF 24
BY DKS DATE 12/14/79
CHK'D. BY PB DATE 12/14/79

YSTAL LAKE DAM- MIDDLETOWN 79-90-1 DKS 12/07/79

FGA FLOOD WAVE ROUTING

APPROXIMATE FLOOD WAVE ROUTING BASED UPON U.S. ARMY CORPS OF ENGINEERS' "RULE OF THUMB GUIDANCE FOR ESTIMATING DOWNSTREAM DAM FAILURE HYDROGRAPHS" DATED APRIL, 1978.

INITIAL STATION = 0 +0
INITIAL WAVE HEIGTH = 50.0 FT
ASSUMED BREACH WIDTH = 28.0 FT
INITIAL RESERVOIR STORAGE = 350 ACRE-FT
COMPUTED FLOOD WAVE PEAK FLOW = 16,634 CFS

STATION 1+60

OFFSET	ELEV.	OFFSET	ELEV.	OFFSET	ELEV.
		N = 0.080			
-450.0 FT	200.0 FT	-80.0 FT	190.0 FT	-10.0 FT	150.0 FT
-10.0 FT	149.0 FT				
		N = 0.040			
-10.0 FT	149.0 FT	-5.0 FT	147.0 FT	5.0 FT	147.0 FT
10.0 FT	149.0 FT				
		N = 0.080			
10.0 FT	149.0 FT	30.0 FT	150.0 FT	70.0 FT	170.0 FT
90.0 FT	180.0 FT	130.0 FT	190.0 FT	220.0 FT	200.0 FT

AREA	WETTED PERIMETER	N	VELOCITY	FLOW
86.3 SF	21.0 FT	0.080	10.6 FPS	919CFS
248.6 SF	20.7 FT	0.040	43.4 FPS	10,811CFS
307.3 SF	42.2 FT	0.080	15.5 FPS	4,793CFS

INVERT	DEPTH	W. SURFACE	AREA	VELOCITY	FLOW	SLOPE
147.0 FT	12.9 FT	159.9 FT	642 SF	25.7 FPS	16,525 CFS	0.0500

STATION 10 +0

N = 0.040

OFFSET	ELEV.	OFFSET	ELEV.	OFFSET	ELEV.
-590.0 FT	160.0 FT	-460.0 FT	150.0 FT	-400.0 FT	140.0 FT
-280.0 FT	130.0 FT	-100.0 FT	120.0 FT	-60.0 FT	110.0 FT
-10.0 FT	107.0 FT	-5.0 FT	105.0 FT	5.0 FT	105.0 FT
10.0 FT	107.0 FT	300.0 FT	110.0 FT	590.0 FT	110.0 FT

AREA	WETTED PERIMETER	N	VELOCITY	FLOW
1,224.8 SF	654.8 FT	0.040	12.6 FPS	15,446CFS

INVERT	DEPTH	W. SURFACE	AREA	VELOCITY	FLOW	SLOPE
105.0 FT	5.9 FT	110.9 FT	1,224 SF	12.6 FPS	15,446 CFS	0.0500

STATION 20 +0

N = 0.040

OFFSET	ELEV.	OFFSET	ELEV.	OFFSET	ELEV.
-900.0 FT	130.0 FT	-600.0 FT	110.0 FT	-400.0 FT	100.0 FT
-170.0 FT	90.0 FT	-10.0 FT	88.0 FT	-5.0 FT	86.0 FT
5.0 FT	86.0 FT	10.0 FT	88.0 FT	700.0 FT	90.0 FT
800.0 FT	90.0 FT	1500.0 FT	90.0 FT	1900.0 FT	100.0 FT
2400.0 FT	110.0 FT	1700.0 FT	150.0 FT		

AREA	WETTED PERIMETER	N	VELOCITY	FLOW
2,182.8 SF	1717.7 FT	0.040	6.0 FPS	13,114CFS

INVERT	DEPTH	W. SURFACE	AREA	VELOCITY	FLOW	SLOPE
86.0 FT	4.7 FT	90.7 FT	2,182 SF	6.0 FPS	13,114 CFS	0.0190

STATION 33 +0

OFFSET	ELEV.	OFFSET	ELEV.	OFFSET	ELEV.
		N = 0.040			
-1280.0 FT	130.0 FT	-920.0 FT	110.0 FT	-820.0 FT	100.0 FT
-510.0 FT	90.0 FT	-100.0 FT	80.0 FT	-10.0 FT	80.0 FT
-5.0 FT	78.0 FT	5.0 FT	78.0 FT	10.0 FT	80.0 FT
200.0 FT	80.0 FT	1080.0 FT	80.0 FT	1370.0 FT	90.0 FT
1850.0 FT	100.0 FT	2000.0 FT	110.0 FT		

AREA	WETTED PERIMETER	N	VELOCITY	FLOW
2,390.1 SF	1313.3 FT	0.040	4.2 FPS	10,252CFS

INVERT	DEPTH	W. SURFACE	AREA	VELOCITY	FLOW	SLOPE
78.0 FT	3.8 FT	81.8 FT	2,390 SF	4.2 FPS	10,252 CFS	0.0060

STATION 51 +0

OFFSET	ELEV.	OFFSET	ELEV.	OFFSET	ELEV.
		N = 0.040			
-1100.0 FT	150.0 FT	-780.0 FT	110.0 FT	-490.0 FT	100.0 FT
-370.0 FT	80.0 FT	-10.0 FT	77.0 FT	-5.0 FT	75.0 FT
5.0 FT	75.0 FT	10.0 FT	77.0 FT	350.0 FT	80.0 FT
530.0 FT	100.0 FT				

AREA	WETTED PERIMETER	N	VELOCITY	FLOW
2,170.1 SF	742.1 FT	0.040	3.3 FPS	7,372CFS

INVERT	DEPTH	W. SURFACE	AREA	VELOCITY	FLOW	SLOPE
75.0 FT	6.4 FT	81.4 FT	2,170 SF	3.3 FPS	7,372 CFS	0.0020

STATION 67 +0

OFFSET	ELEV.	OFFSET	ELEV.	OFFSET	ELEV.
		N = 0.040			
-800.0 FT	120.0 FT	-400.0 FT	100.0 FT	-100.0 FT	90.0 FT
-80.0 FT	80.0 FT	-30.0 FT	73.0 FT	30.0 FT	73.0 FT
50.0 FT	80.0 FT	150.0 FT	100.0 FT	400.0 FT	120.0 FT

AREA	WETTED PERIMETER	N	VELOCITY	FLOW
1,329.4 SF	165.0 FT	0.040	4.7 FPS	6,275CFS

INVERT	DEPTH	W. SURFACE	AREA	VELOCITY	FLOW	SLOPE
73.0 FT	11.5 FT	84.5 FT	1,329 SF	4.7 FPS	6,275 CFS	0.0010

STATION 78 +0

OFFSET	ELEV.	OFFSET	ELEV.	OFFSET	ELEV.
		N = 0.040			
-1100.0 FT	150.0 FT	-600.0 FT	100.0 FT	-420.0 FT	90.0 FT
-170.0 FT	80.0 FT	-10.0 FT	72.0 FT	-5.0 FT	70.0 FT
5.0 FT	70.0 FT	10.0 FT	72.0 FT	330.0 FT	90.0 FT
600.0 FT	100.0 FT	850.0 FT	120.0 FT		

AREA	WETTED PERIMETER	N	VELOCITY	FLOW
,311.4 SF	312.9 FT	0.040	4.3 FPS	5,662CFS

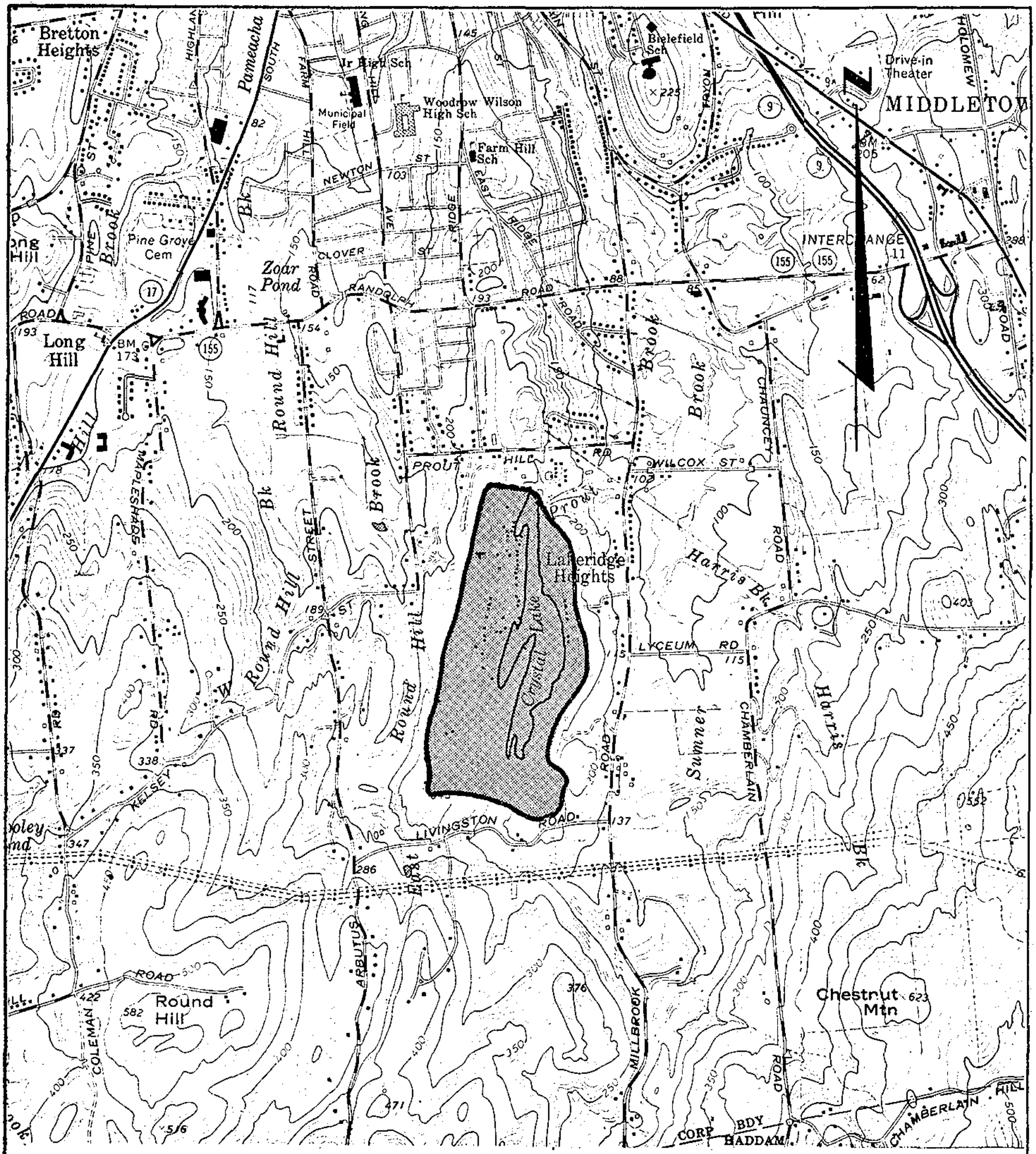
INVERT	DEPTH	W. SURFACE	AREA	VELOCITY	FLOW	SLOPE
70.0 FT	9.7 FT	79.7 FT	1,311 SF	4.3 FPS	5,662 CFS	0.0020

STATION 98 +0

OFFSET	ELEV.	OFFSET	ELEV.	OFFSET	ELEV.
		N = 0.040			
-450.0 FT	60.0 FT	-300.0 FT	50.0 FT	-90.0 FT	40.0 FT
-10.0 FT	17.0 FT	-5.0 FT	15.0 FT	5.0 FT	15.0 FT
10.0 FT	17.0 FT	250.0 FT	50.0 FT	350.0 FT	60.0 FT

AREA	WETTED PERIMETER	N	VELOCITY	FLOW
377.0 SF	90.7 FT	0.040	14.2 FPS	5,368CFS

INVERT	DEPTH	W. SURFACE	AREA	VELOCITY	FLOW	SLOPE
15.0 FT	8.3 FT	23.3 FT	377 SF	14.2 FPS	5,368 CFS	0.0220



CRYSTAL LAKE DAM

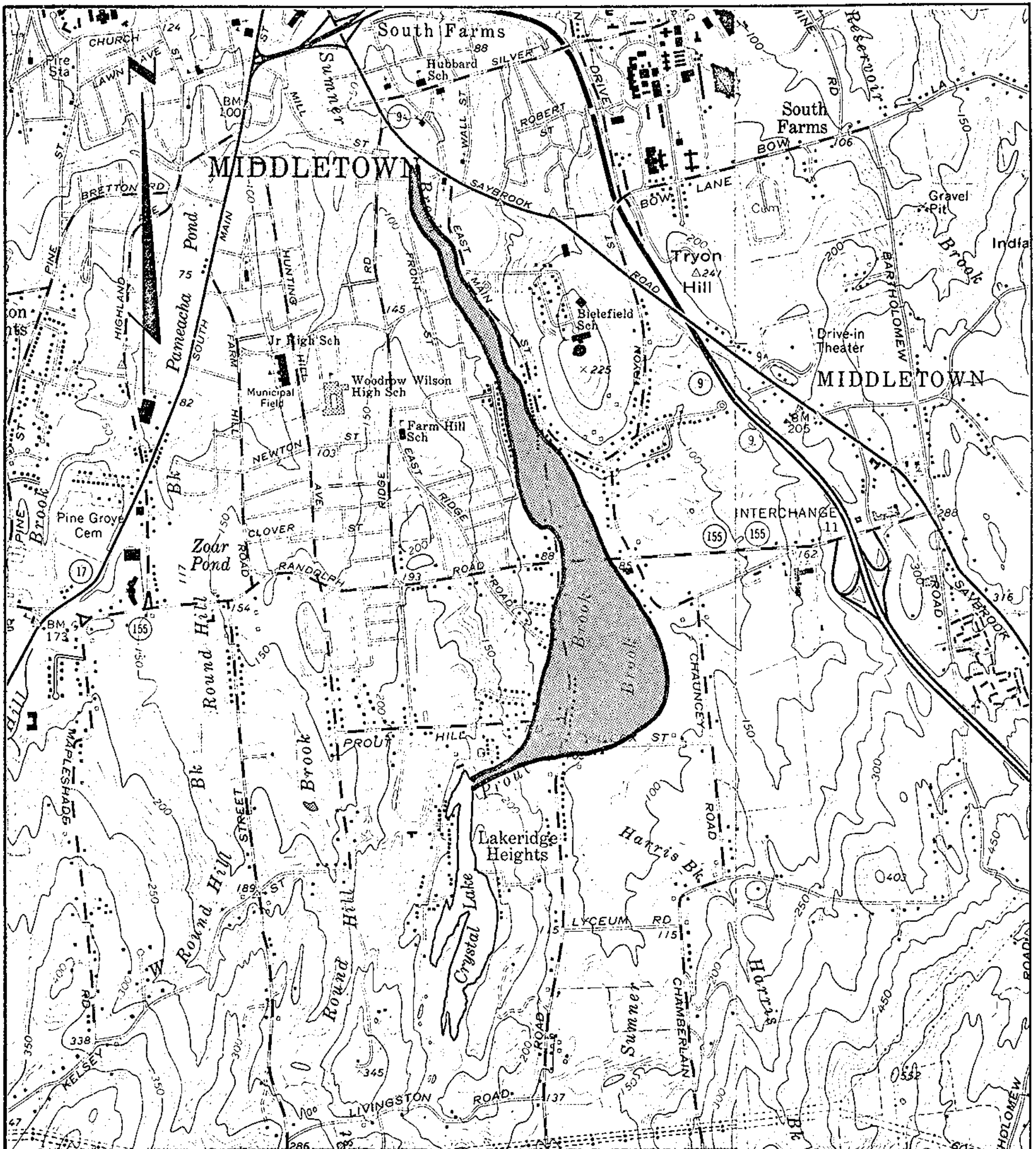
DRAINAGE MAP

MIDDLETOWN , CONNECTICUT

SCALE IN FEET

2000 1000 0 2000

FLAHERTY • GIAVARA ASSOCIATES, P.C.



CRYSTAL LAKE DAM

DAM FAILURE ANALYSIS

IMPACT AREAS

MIDDLETOWN, CONNECTICUT

SCALE IN FEET

2000 1000 0 2000

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APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS