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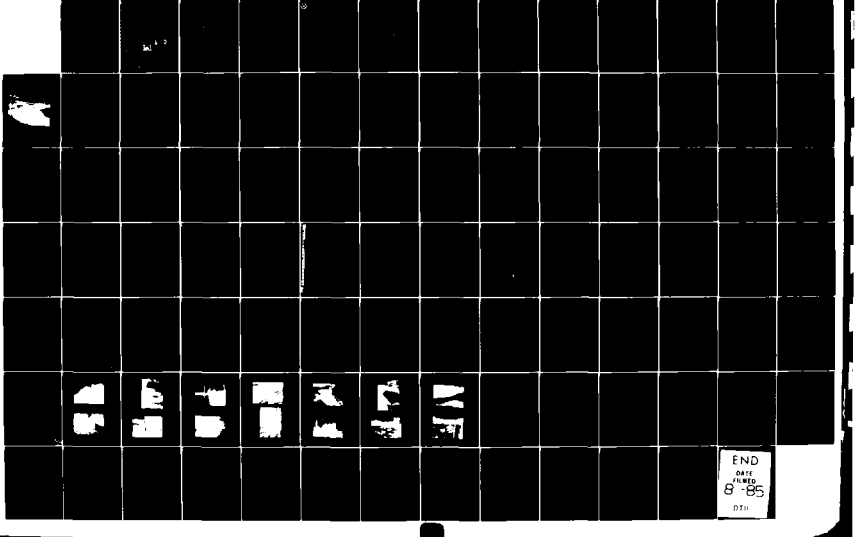

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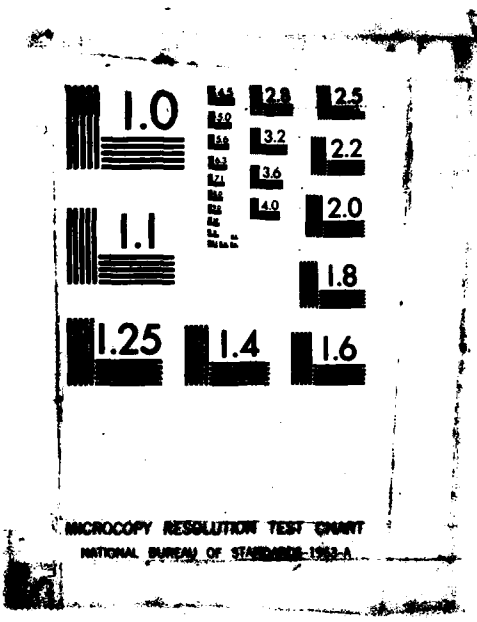
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BLACKSTONE RIVER BASIN
NORTHBRIDGE, MASSACHUSETTS

LINWOOD POND DAM

MA 00896

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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

JUNE 1980

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4. TITLE (and Subtitle) Linwood Pond Dam NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS		5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT 6. PERFORMING ORG. REPORT NUMBER
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9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
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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,

Blackstone River Basin
Northbridge, Massachusetts
Mumford River

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

The dam is a 688 ft. long composite masonry, timber, and earth embankment dam consisting of a 116 ft. long gravity masinry overflow section with a timber sill and sloping timber upstream face. It is small in size with a hazard potential of high. The dam is judged to be in generally fair condition. The training walls of the spillway are in need of repair. The low level outlet is reported to be operative.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF:

NEDED-E

NOV 17 1980

Honorable Edward J. King
Governor of the Commonwealth of
Massachusetts
State House
Boston, Massachusetts

Dear Governor King:

Inclosed is a copy of the Linwood Pond Dam (MA-00896) Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. The report is based upon a visual inspection, a review of past performance, and a preliminary hydrological analysis. A brief assessment is included at the beginning of the report.

The preliminary hydrologic analysis has indicated that the spillway capacity for the Linwood Pond Dam would likely be exceeded by floods greater than 10 percent of the Probable Maximum Flood (PMF), the test flood for spillway adequacy. Our screening criteria specifies that a dam of this class which does not have sufficient spillway capacity to discharge fifty percent of the PMF, should be adjudged as having a seriously inadequate spillway and the dam assessed as unsafe, non-emergency, until more detailed studies prove otherwise or corrective measures are completed.

The term "unsafe" applied to a dam because of an inadequate spillway does not indicate the same degree of emergency as that term would if applied because of structural deficiency. It does indicate, however, that a severe storm may cause overtopping and possible failure of the dam, with significant damage and potential loss of life downstream.

It is recommended that within twelve months from the date of this report the owner of the dam engage the services of a professional or consulting engineer to determine by more sophisticated methods and procedures the magnitude of the spillway deficiency. Based on this determination, appropriate remedial mitigating measures should be designed and completed within 24 months of this date of notification. In the interim a detailed emergency operation plan and warning system should be promptly developed. During periods of unusually heavy precipitation, round-the-clock surveillance should be provided.

NOV 17 1980

NEDED-E
Honorable Edward J. King

I have approved the report and support the findings and recommendations described in Section 7, with qualifications as noted above. I request that you keep me informed of the actions taken to implement these recommendations since this follow-up is an important part of the non-Federal Dam Inspection Program.

A copy of this report has been forwarded to the Department of Environmental Quality Engineering, the cooperating agency for the Commonwealth of Massachusetts. This report has also been furnished to the owner of the project, the Lusignan Corporation, Linwood, Mass.

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

I wish to take this opportunity to thank you and the Department of Environmental Quality Engineering for the cooperation extended in carrying out this program.

Sincerely,

WILLIAM E. HODGSON, JR.
Colonel, Corps of Engineers
Acting Division Engineer

LINWOOD POND DAM

MA 00896

BLACKSTONE RIVER BASIN
NORTHBRIDGE, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT

Identification No.:	MA 00896
Name of Dam:	Linwood Pond Dam
Town:	Northbridge
County and State:	Worcester County, Massachusetts
Stream:	Mumford River
Date of Inspection:	17 April 1980

BRIEF ASSESSMENT

Linwood Pond Dam is a 688 ft. long composite masonry, timber, and earth embankment dam consisting of a 116 ft. long gravity masonry overflow section with a timber sill and sloping timber upstream face, a 282 ft. long earth embankment to the right of the overflow section and a 290 ft. long earth embankment to the left of the overflow section. The facility also has a dike which runs parallel to the Mumford River. The dike extends from the left end of the left embankment downstream for a distance of about 276 ft. It is formed by a portion of Linwood Avenue and an adjacent parking lot which serves the mill located just downstream of the left embankment. Linwood Pond once served the water needs of this mill complex, but water from the pond is no longer used at the mill. The pond serves as a source of irrigation water for a golf course upstream of the dam. There is a low level outlet for the dam which is located in the left embankment. The size and invert elevation of the low level outlet are unknown.

The pond is about 3,700 ft. long and has a surface area of about 48 acres at spillway crest level. The drainage area is 50.4 sq. mi. and the maximum storage to top of dam is about 590 acre-ft. The height of the dam is 17.5 ft.; the size classification is thus small. Because failure of the dam could cause serious damage two houses, two mills, and three commercial structures, with the possibility of the loss of more than a few lives and the probability of excessive economic losses, the dam has been classified as having a high hazard potential. Based on the guidelines the recommended test flood ranges from ½ PMF to a full PMF. A test flood equal to ½ PMF (17,600 cfs) was selected. Since storage in the pond above the dam is insignificant and inflow is approximately equal to outflow, a test flood routing was not performed.

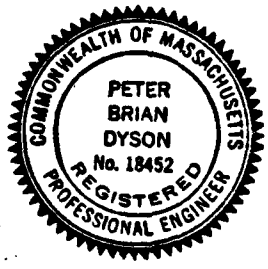
The test flood of 17,600 cfs overtops the dam's earth embankments by 3.4 ft. The spillway can pass 3,550 cfs or about 20 percent of the test flood without overtopping the embankments.

The dam is judged to be in generally fair condition. Water was flowing to a depth of about 7 in. over the crest of the spillway at the time of the inspection, so it was not possible to observe the condition of the downstream face or the crest of the overflow section. Nevertheless, the water appeared to be flowing uniformly with no evidence of turbulence or missing or eroded elements. Seepage was noted below the right embankment and through the berm between the reservoir rim and an abandoned gravel pit located to the right of the right embankment. Minor erosion was noted on both embankments and there is brush and tree growth on both the dike and the right embankment. The training walls of the spillway are in need of repair. The low level outlet is reported to be operative.

Within one year after receipt of this Phase I Inspection Report, the owner, the Lusignan Corporation, should retain the services of a registered professional engineer and implement the results of his evaluation of the following: (1) assess further the potential for overtopping and the adequacy of the spillway; (2) inspect the spillway during a period of low flow or no flow conditions: (3) study and monitor the seepage emanating from the right reservoir rim into the abandoned gravel pit located to the right of the right embankment; (4) study the seepage emanating from the right embankment: (5) investigate the structural integrity of the right reservoir rim; (6) removal of trees and heavy brush growth from the upstream slope of the dike and inspection of the condition of the slope (7) removal of trees and brush growth from both slopes of the right embankment; and (8) determine the need to relocate the two fire hydrants located on the dam.

The owner should also implement the following operating and maintenance measures: (1) repair and repoint the mortar joints in the left and right spillway training walls, including resetting dislodged capstones; (2) repair erosion areas on the upstream slope of the left embankment adjacent to the low level outlet and the left spillway training wall, and on the downstream slope of the right embankment near the right training wall; (3) develop a formal surveillance and downstream emergency warning plan, including round-the-clock monitoring during periods of high precipitation; (4) institute procedures for an annual periodic technical inspection of the dam and its appurtenant structures, including operation of the low level outlet and the condition of the concrete plug in the abandoned outlet conduit; (5) remove debris from the downstream spillway channel; and (6) implement a regular periodic maintenance program.

Peter B. Dyson
Project Manager



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

Carney M. Terzian

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

Richard J. DiBuono

RICHARD DIBUONO, MEMBER
Water Control Branch
Engineering Division

ARAMAST MAHTESIAN, CHAIRMAN
Geotechnical Engineering Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Frye

JOE B. FRIAR
Chief, Engineering Division

PREFACE

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

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

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

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

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

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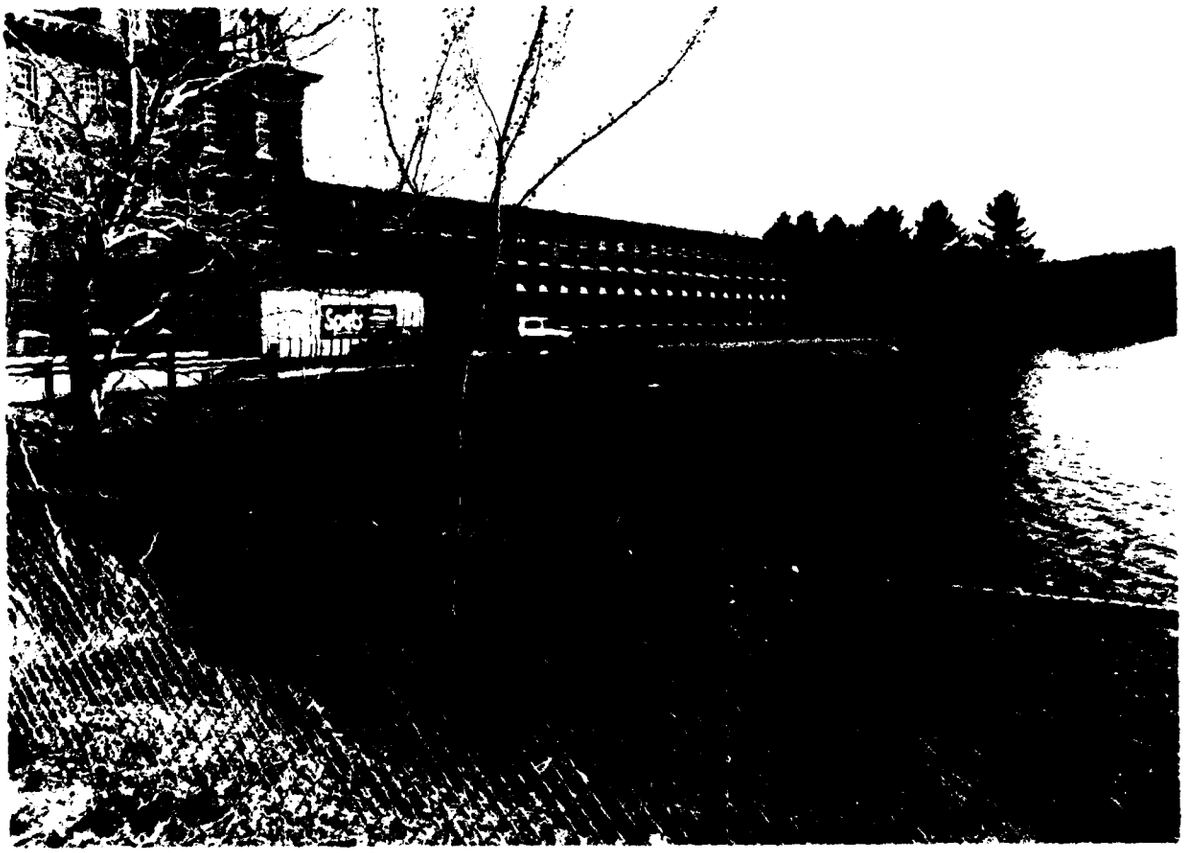
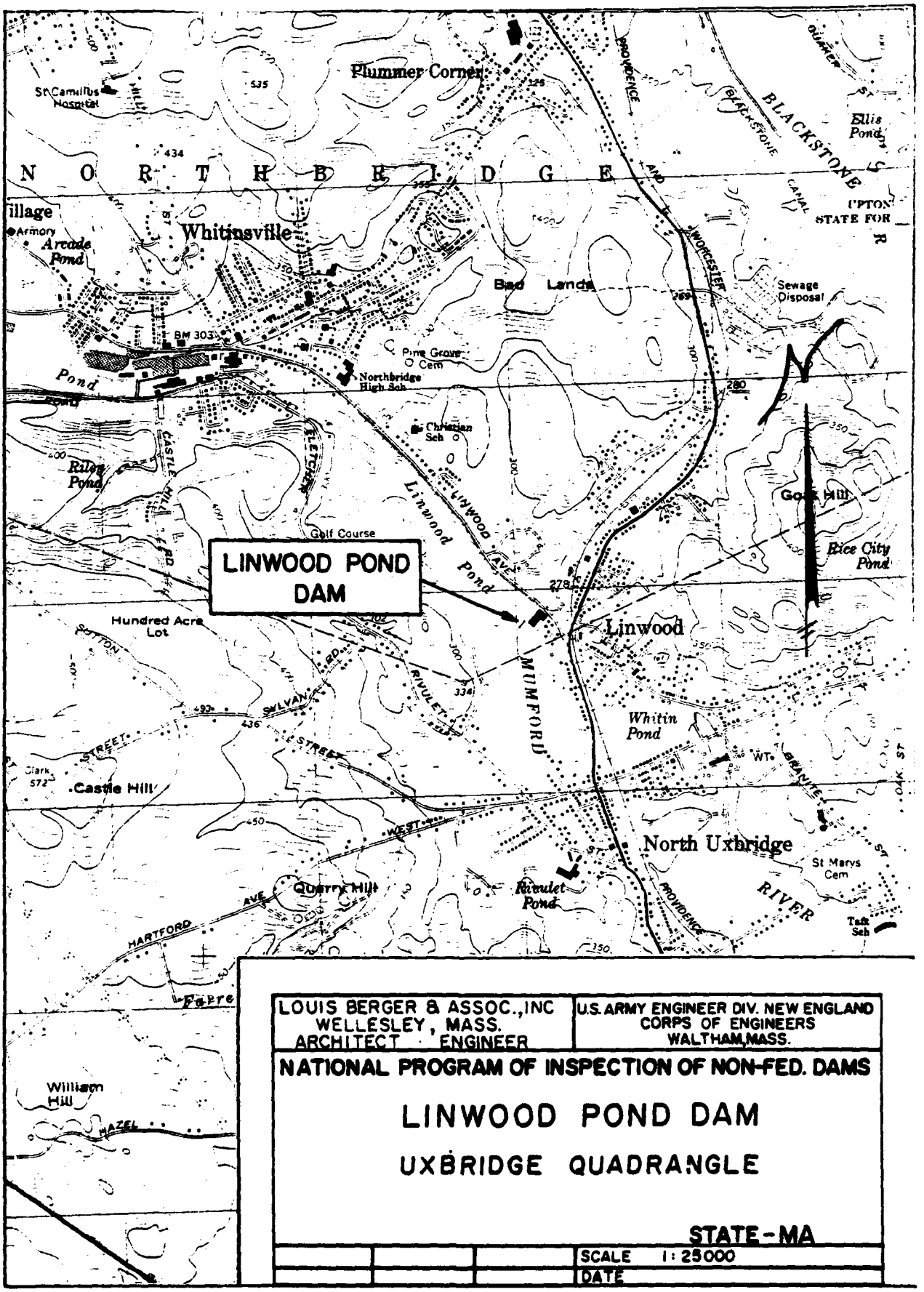
LINWOOD POND DAM



OVERVIEW FROM LEFT ABUTMENT



LOUIS BERGER & ASSOC., INC WELLESLEY, MASS. ARCHITECT ENGINEER	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LINWOOD POND DAM

UXBRIDGE QUADRANGLE

STATE - MA

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DATE	

PHASE I INSPECTION REPORT

LINWOOD POND DAM MA 00896

SECTION 1 - PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Louis Berger & Associates, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Authorization and notice to proceed was issued to Louis Berger & Associates, Inc. under a letter of 28 March 1980 from William E. Hodgson, Jr., Colonel, Corps of Engineers. Contract No. DACW33-80-C-0043 has been assigned by the Corps of Engineers for this work.

b. Purpose of Inspection

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

1.2 Description of Project

a. Location. Linwood Pond and Dam are located on the Mumford River about 2.7 miles upstream from the river's confluence with the Blackstone River. The dam site is in the Town of Northbridge, Worcester County, Massachusetts. The dam lies just west of State Route 122 in the village of Linwood. It is shown on U.S.G.S. Quadrangle, Uxbridge, Mass.-R.I., with coordinates approximately at N 42° 05' 52", W 71° 38' 23".

b. Description of Dam and Appurtenances. Linwood Pond Dam is a run-of-the-river dam believed to have been constructed around 1865 as a diversion dam to furnish water for a mill located just downstream of the dam on the left bank of the Mumford River.

Essentially, the dam consists of an overflow section which is 4.5 ft. below the top of dam, an earth embankment on each side of the overflow section, a dike, a low level outlet and an abandoned intake structure leading to the mill.

The left embankment is approximately 290 ft. long, has a crest width of 16 ft. and a 3 horizontal to 1 vertical downstream slope with a maximum height of about 8 ft. The embankment is located just upstream of the mill buildings and the left end of the embankments is crossed by a driveway leading into the mill complex. The right embankment is about 282 ft. long, has a crest width of 16 ft. and a 3 horizontal to 1 vertical downstream slope with a maximum height of about 16 ft. The right end of the embankment meets natural ground in close proximity to a gravel pit which is

located just beyond the downstream end of the right reservoir rim. As mentioned above, the left embankment intersects a driveway which connects the mill parking lot and Linwood Avenue. This parking lot and Avenue form a dike between a portion of Linwood Pond that lies left of Linwood Avenue, and the main mill building. The dike is about 276 ft. long, has a variable width (about 100 ft. or greater), and its crest is paved with asphalt and concrete. There is an abandoned intake at the downstream end of the dike which leads to an enclosed conduit which passes through the mill. The abandoned intake has 4 gates. There are two pressure fire hydrants along the crest of the left embankment.

The overflow section or spillway has a crest length of about 116 ft. The spillway has a timber apron on the upstream slope, a timber sill, and a vertical face about 5 ft. high on the downstream side which intersects a sloping dumped granite block apron leading to the natural river channel. The spillway has 5 ft. high rubble masonry gravity training walls which also form the training walls for the downstream spillway outlet channel (see photographs in Appendix C).

There is a low level outlet for the facility located about 15 ft. left of the left spillway training wall. The invert elevation and size of the stone box culvert are undetermined. The control for the outlet is hand operated and the low level discharges are returned to the Mumford River through the training wall just downstream of the spillway. The low level outlet is reported to be in good working condition and operated two to three times per year.

c. Size Classification. Linwood Pond Dam has a hydraulic height of about 17.5 ft. above downstream river level, and impounds a normal storage of about 300 acre-ft. to spillway crest level and a maximum of about 590 acre-ft. to top of dam. In accordance with the size and capacity criteria given in Recommended Guidelines for Safety Inspection of Dams, the project falls into the small category on the basis of height and capacity and is therefore classified accordingly.

d. Hazard Classification. A breach failure of Linwood Pond Dam would release water down the Mumford River to its confluence with the Blackstone River about 2.7 miles downstream. The mill located just downstream of the dam on the left bank of the Mumford River would sustain seridus flooding if a breach should occur. Two houses in the area of the Whitin Pond Dam located about 4,200 ft. below Linwood Pond Dam would sustain serious flooding. There it is estimated that the already swollen river would rise about 5 ft. as it overtopped the Whitin Pond Dam. About 2.2 miles below Linwood Pond Dam there is another impoundment of the Mumford River, Caprons Pond Dam. Here it is estimated that the stage would rise about 3 ft. as the breach surge passed over the dam. Three commercial buildings containing shops and stores would sustain flood damage in th's area. In the next reach beyond Caprons Pond Dam the river channel is narrow and it is estimated that the river stage would rise about 6 ft. in this area, damaging a mill complex which is located along the banks of the river. Beyond this point, about 0.5 mile downstream, the Mumford River joins the Blackstone River where the flood wave should be significantly reduced in the wide Blackstone River Valley. It is estimated that in all the damage areas the depth of flooding of structures due to the breach would increase from about a one foot depth just prior to failure to a depth of from 4 to 6 ft. after failure of the dam. In accordance with the Recommended Guidelines for Safety Inspection of Dams, Linwood Pond Dam has therefore been classified as having a high hazard potential since failure would cause serious damage to homes, commercial establishments, and mill complexes, with the potential for the loss of more than a few lives.

e. Ownership. Linwood Pond Dam is owned by the Lusignan Corporation, 666 Linwood Avenue, Linwood, Massachusetts, 01525, telephone: 617-234-6251.

Worcester County Dam Inspection Sheets indicate past ownership of the dam as follows:

1924 thru 1938 - Whitin Brothers, Inc.
1940 - Paul Whitin Manufacturing Company
1953 thru 1962 - Whitin Machine Company
1963 - Stylon Corporation

f. Operator. Mr. Paul Lusignan, c/o Lusignan Corporation, 666 Linwood Avenue, Linwood, Massachusetts 01525, telephone: 617-234-6251.

g. Purpose of Dam. It is believed that the dam was originally constructed to furnish power needs for the mill located just downstream of the dam. The intake to the mill is now blocked off completely by a concrete plug and the mill does not use any water from the pond. Linwood Pond Dam therefore no longer serves its original purpose, but it is said to be used as a source of irrigation water for a golf course upstream. The owner has also expressed an interest in converting the dam back into a low head hydroelectric facility.

h. Design and Construction History. A Worcester County Dam Inspection Report indicates that the dam was constructed in 1865 by a G. Blanchard. No other reports or drawings have been found pertaining to design and construction of the dam.

i. Normal Operating Procedures. The only operating device for the dam is the low level outlet which is operative and is opened at times of high flow. There are no formal operating procedures for the dam.

1.3 Pertinent Data

a. Drainage Area. The drainage area above Linwood Pond Dam consists of about 50.4 sq. mi., described in general as rolling terrain. The watershed contains several reservoirs, lakes and ponds, the largest bodies of water being Whitin Reservoir, Manchaug Pond and Crystal Lake in the upper reaches of the watershed. These three bodies of water have a total drainage area of about 15.5 sq. mi. and would retard a moderate amount of the runoff from the upper reaches of the drainage area... Other relatively large bodies of water are Lackey Pond and Whitens Pond both impoundments of the Mumford River. These two Ponds are impounded by run-of-the-river dams and would have a lesser affect than the three other ponds on the runoff from the drainage basin. In general, the drainage area is heavily wooded, but contains some open fields and populated areas. The most heavily populated area is in the southern part of the watershed in the village of East Douglas and just upstream of Linwood Pond Dam in the community of Whitinsville.

b. Discharge at Damsite

(1) Outlet Works Conduit. Though a low level outlet exists for Linwood Pond Dam, the size and invert elevation could not be ascertained. Therefore, the discharge capacity of the outlet is unknown, but it is reported to be in working condition.

(2) Maximum Known Flood at Damsite. The maximum known discharge at the damsite is unknown. U.S.G.S. Water-Supply Paper 798, The Floods of March 1936, reports that the maximum discharge on the Mumford River at a point about 2.3 mi. downstream of the dam was 3,570 cfs on March 19, 1936. The drainage area above this point of recorded discharge is 57 sq. mi. compared with a drainage area above Linwood Pond Dam of about 50 sq. mi. A Worcester County inventory sheet for the dam reports that the 1938 Flood topped the dam by 0.5 ft. An Inspection Report made by the Worcester County Engineer dated October 19, 1938 states, "apparently the flood topped the embankment by a small amount (5 or 6 in.)" Another County Dam Inspection Report for the dam dated October 6, 1961, states, "Repaired after 1955 Flood", though there is no record of the flood stage.

(3) Ungated Spillway Capacity at Top of Dam. The total spillway capacity at top of dam, elevation 270.5, is about 3,550 cfs.

(4) Ungated Spillway Capacity at Test Flood Elevation. The ungated spillway capacity is about 8,100 cfs at test flood elevation 273.9

(5) Gated Spillway Capacity at Normal Pool Elevation. Not applicable

(6) Gated Spillway Capacity at Test Flood Elevation. Not applicable

(7) Total Spillway Capacity at Test Flood Elevation. The total spillway capacity at the test flood elevation is the same as (4) above, 8,100 cfs at test flood elevation 273.9

(8) Total Project Discharge at Top of Dam. The discharge capability of the low level discharge outlet could not be ascertained. It is estimated that the total project discharge would only be slightly greater than the spillway discharge of 3,550 cfs at elevation 270.5.

(9) Total Project Discharge at Test Flood Elevation. The total project discharge is 17,600 cfs at test flood elevation 273.9

c. Elevation (ft. N.G.V.D.)

(1) Streambed at toe of dam - 253

(2) Bottom of Cutoff - Unknown

(3) Maximum tailwater - Unknown

(4) Recreation pool - Not applicable

(5) Full flood control pool - Not applicable

(6) Spillway crest - 266

(7) Design surcharge (Original Design) - Unknown

(8) Top of dam - 270.5

(9) Test flood surcharge - 273.9

d. Reservoir (Length in feet)

(1) Normal pool - 3,700

(2) Flood control pool - Not applicable

(3) Spillway crest pool - 3,700

(4) Top of dam - 5,600

(5) Test flood pool - 6,900

e. Storage (acre-feet)

(1) Normal pool - 300

(2) Flood control pool - Not applicable

(3) Spillway crest pool - 300

(4) Top of dam - 590

(5) Test flood pool - 910

f. Reservoir Surface (acres)

(1) Normal pool - 48.7

(2) Flood-control pool - Not applicable

(3) Spillway crest - 48.7

(4) Top of dam - 81

(5) Test flood pool - 112

g. Dam

(1) Type - Masonry gravity overflow section and earth non-overflow sections

(2) Length - 688 ft.

(3) Height - 17.5 ft.

(4) Top Width - 16 ft.

(5) Side Slopes - Non-overflow section: Upstream - Unknown
Downstream - 2 horizontal to 1 vertical

(6) Zoning - Unknown

(7) Impervious Core - Unknown

(8) Cutoff - Unknown

(9) Grout Curtain - Unknown

Dike

(1) Type - Earthfill

(2) Length - 276 ft.

(3) Height - 17.8 ft.

(4) Top Width - 100 ft. (approximate)

(5) Side Slopes - Upstream - Unknown; Downstream - varies - vertical to generally gentle

(6) Zoning - Unknown

(7) Impervious Core - Unknown

(8) Cutoff - Unknown

(9) Grout Curtain - Unknown

h. Diversion and Regulating Tunnel - None

i. Spillway

(1) Type - Masonry gravity with wooden crest

(2) Length of Weir - 116 ft.

(3) Crest elevation - 266 ft.

(4) Gates - None

(5) U/S Channel - Natural river channel

(6) D/S Channel - Dumped granite block apron with training walls leading to natural river channel.

j. Regulating Outlets

(1) Invert - Unknown*

(2) Size - Unknown*

(3) Description - Masonry box culvert

(4) Control Mechanism - Hand operated

(5) Other * A Worcester County Inventory Sheet (see Appendix B) reports that the waste gate is 3 ft. X 3.5 ft. at an elevation 5.5 ft. below the spillway crest.

SECTION 2 - ENGINEERING DATA

2.1 Design Data

No data on the design of the dam or appurtenances has been recovered. In the course of the inspection a sketch of the dam was made and is included in Appendix B.

2.2 Construction Data

No records or correspondence regarding construction have been found with the exception of a Worcester County Dam Inspection Report which indicates that the dam was constructed in 1865 by a G. Blanchard. It was reported by the owner that the pond was drained in 1975 and repairs performed on the masonry and timber sections of the spillway.

2.3 Operation Data

There are no formal operating records for the dam. It was reported by the owner that the low level outlet is opened at times of high flow in the river.

2.4 Evaluation of Data

a. Availability. Since no engineering data is available, it is not possible to make an assessment of the safety of the dam. The basis of the information presented in this report is principally the visual observations of the inspection team.

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

c. Validity. Not applicable.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

a. General. The visual inspection of Linwood Pond Dam took place on April 17, 1980. On that date water was flowing about 0.6 ft. deep over the spillway and the discharge was estimated to be about 170 cfs. The dam was judged to be in fair condition. The major cause for concern was seepage at two locations. In addition, several other items require attention (see Section 7).

b. Dam.. The dam is a run-of-the-river dam with an overall length of about 588 ft. The facility also has a dike which extends downstream from the left end of the left embankment paralleling the river for a distance of about 276 ft. In addition to the dike, the other principal elments of the dam are an ashlar faced gravity overflow section, earth embankments, an abandoned conduit which passes through a mill located just downstream of the left embankment, and a low level outlet.

Starting from the right, there is an earth embankment about 282 ft. long which intersects natural ground on the far right not too far from an abandoned gravel pit. The embankment has a maximum height of about 16 ft., a crest width of about 16 ft. and a 3 horizontal to 1 vertical downstream slope. This embankment exhibits some seepage along the downstream toe from a point approximately 50 ft. right of the spillway, and for a distance to the right of perhaps 50 ft. and 10 ft. downstream of the toe. There is heavy brush and tree growth on both the downstream and upstream slopes of this embankment. There is minor erosion on the downstream slope of the right embankment near the training wall of the spillway (see Appendix C, Photo Nos. 1 & 2).

The right shoreline upstream of the right embankment is separated from a gravel pit by an irregular earth berm that has been formed as the result of a gravel pit operation. This area exhibits seepage in the direction of the gravel pit and requires further investigation to determine the stability of the berm slopes. These slopes appear to be about one and one-half (1½) to one on the downstream side and upstream they are covered with heavy tree and brush growth. The floor of the gravel pit in this area is lower than the normal water surface of Linwood Pond and the seepage is quite substantial over a relatively large area. A general reconnaissance was made of the mined out gravel pit and the whole rim of the pit appears to be generally higher than the reservoir level. Therefore, any outflow from a breach of the reservoir rim into the gravel pit would probably be contained within the pit and then returned to the river through a shallow ravine downstream of the dam. However, this should be verified by a more detailed survey (see Appendix C, Photos Nos. 6,7 & 8). This area is reportedly owned by a Mr. Devries and not by the Lusignan Co. who is the owner of the dam.

The left embankment starts at the Linwood Avenue Dike and extends to the right for a distance of about 290 ft. to the spillway. The crest of the embankment is about 16 ft. wide and has a maximum height of about 8 ft. The downstream slope is 3 horizontal to 1 vertical. A mill complex is located just downstream of the left embankment. The embankment is generally in good condition. The upstream slope is covered with a light cobblestone slope protection generally less than 6 in. in size. However, there is some erosion on the upstream slope just to the left of the spillway and also near the low level outlet. The downstream slope is sodded and well maintained, and it appears to be in good condition with no evidence of sloughing or slope movement. No seeepage could be seen along the toe which is in close proximity to the mill building. The downstream toe of the embankment is paved (see Appendix C, Photo Nos. 3 & 4) There are two pressure fire hydrants on the crest of the left embankment.

Linwood Avenue Dike. A portion of Linwood Avenue and the mill complex's parking lot acts as a dike retaining part of Linwood Pond in a catchment which lies to the left of Linwood Avenue. The dike is about 276 ft. long and has a wide crest with a minimum width of about 100 ft. A culvert located just upstream of the dike and under Linwood Avenue connects the two parts of the pond. The Linwood Avenue Dike is covered with heavy brush and tree growth on the upstream slope. Because of the heavy growth, the condition of the upstream slope could not be determined. The dike runs parallel to the Mumford River. On its downstream end there is an abandoned gate structure which leads to a conduit which passes through the mill and connects back to the Mumford River. The intake to the conduit has been blocked off completely by a concrete plug and no longer serves any useful purpose (see Appendix C, Photo Nos. 5 & 10).

c. Appurtenance Structures

(1) Spillway. The overflow section of the dam is about 116 ft. long and lies between the left and right embankments. The overflow section is a masonry gravity structure with a timber apron on the upstream face and a timber sill on its crest. There is a 5 ft. vertical drop from the crest to a sloping, dumped granite block apron which slopes down to the natural channel of the Mumford River. The spillway is separated from the embankments by 4.5 ft. high rubble masonry gravity walls which form the left and right training walls of the spillway. Both the left and right training walls are in need of resetting and repointing and several capstones are displaced. At the time of the inspection water was flowing about 7 in. above the crest of the spillway, so it was not possible to observe the condition of the downstream toe or crest of the overflow section. Nevertheless, the water appears to be flowing uniformly with no evidence of turbulence or missing or eroded elements (see Appendix C, Photo Nos. 11, 12, 13 & 14).

(2) Low Level Outlet. There is a low level outlet for the facility which is located in the left embankment about 15 ft. left of the left spillway training wall. The control for the outlet is hand operated and the conduit is believed to be a granite block structure. The downstream end of the outlet can be seen on Photograph No. 12. The invert elevation and conduit size could not be ascertained. A Worcester County Inventory Sheet reports that the size is 3 ft. x 3½ ft. The owner has indicated that the outlet is in good working order and is opened two to three times per year. The owner also stated that the outlet was used about five years ago to lower the pond when repairs were made to the spillway of the dam (see Appendix C, Photo No.9).

d. Reservoir Area. The reservoir shores appear stable except in the area discussed under (b) above where the rim of the reservoir is adjacent to the mined out gravel pit, near the right end of the right embankment. Seepage through the rim of the reservoir into the gravel pit was noted in this area and should be investigated further. Linwood Avenue parallels the left side of the reservoir for its entire length. A golf course is located on the right side of the reservoir near its upstream end.

e. Downstream Channel. Immediately downstream of the dam there is a mill located on the left side of the river. The left training wall for the spillway extends downstream for quite some distance as the river passes the mill. The right bank of the river bed is rather low and covered with brush. There is some debris lodged in the granite block apron of the spillway but the remainder of the channel appears unobstructed. About 4,200 ft. below the dam there is another impoundment of the Mumford River known as Whitin Pond, located in the village of North Uxbridge. About

7,000 ft. below Whitin Pond in the village of Uxbridge is another dam along the river forming Caprons Pond. Below the Caprons Pond dam the river channel is narrow until it joins the Blackstone River about 0.5 mile below the Caprons Pond Dam.

3.2 Evaluation

The visual inspection of the dam adequately revealed key characteristics as they may relate to its stability and integrity, permitting an assessment to be made of those features affecting the safety of the structure. The Linwood Pond Dam, dike and appurtenant works are judged to be in generally fair condition. Seepage was noted near the toe of the right embankment and through the rim of the reservoir leading to a mined out gravel pit located just to the right of the righ embankment. There is considerable tree and brush growth on the right embankment and on the upstream slope of the Linwood Avenue Dike. The spillway training walls are in need of resetting and repointing and there is a minor amount of erosion on both embankments. The low level was reported to be operative. For these reasons the dam, dike and appurtenant works are judged to be in only fair condition.

SECTION 4 - OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operational Procedures

a. General. Linwood Pond Dam is operated by the Lusignan Corporation. The only operating device is the low level gated conduit through the left embankment. The control gate is normally kept closed, but it is opened when discharges are high in the Mumford River. There are no formal operating procedures for the dam.

b. Description of any Warning System in Effect. No warning system is in effect at Linwood Pond Dam.

4.2 Maintenance Procedures

a. General. No regular periodic maintenance program is in effect at Linwood Pond Dam. There are however several items which require periodic maintenance such as: the upkeep of sod on the crest and downstream slope of the dam; the removal of growth from the embankments and the dike; the removal of debris from the spillway crest and downstream channel; the repair of the spillway training walls; the surveillance of the embankment regarding seeps, slope damage and animal burrows; and, the maintenance of the outlet gate.

b. Operating Facilities. The only existing operating facility for the dam is the low level outlet which appears to be well maintained. The conduit leading to the mill at the downstream end of the Linwood Avenue Dike has been abandoned and sealed with a concrete plug.

4.3 Evaluation

Overall maintenance of the dam is generally fair. Specific maintenance items are evaluated as follows: the sod on the crest and downstream slope of the left embankment is in good condition; brush and trees are well established on the right embankment and dike, and need to be removed; the spillway crest is relatively free of debris; the downstream spillway channel needs to be cleared of debris; there is mortar missing from the joints of the spillway training walls; there is seepage at the toe of the right embankment and at the right reservoir rim; no seeps were evident along the left embankment or dike; the low level outlet is in operating condition. The owner should establish a formal warning system for the dam in the event of an emergency.

SECTION 5 - EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

5.1 General

Linwood Pond Dam consists of a masonry, gravity overflow section flanked by earth embankments and a dike formed by a roadway and parking lot fill. The dam impounds a normal storage of about 300 acre-ft. with provisions for an additional 290 acre-ft. of capacity in its surcharge space to top of dam. It is a run-of-the-river dam and is basically a high spillage-low storage facility. The spillway is capable of discharging about 3,550 cfs with the surcharge to the top of dam. The general topographic characteristics of the 50.4 sq. mi. drainage area is best described as rolling terrain, which rises from elevation 266.0 at spillway crest to elevation 920. The area contains numerous reservoirs, lakes, and ponds both in the upper reaches and along the Mumford River. In the upper reaches of the drainage area are located Whitin Reservoir, Manchaug Pond, and Crystal Lake. The drainage area above these bodies of water in the basin are Lackey Pond and Whitens Pond, both impoundments of the Mumford River. The effect of these impoundments on the runoff from the basin were considered in this study in arriving at the test flood value for Linwood Pond Dam, and should be considered further in the more detailed hydrology study recommended in Section 7. The area contains both open fields and forests but is predominately forested.

5.2 Design Data

No hydrologic computations or hydraulic data has been recovered for the dam.

5.3 Experience Data

No formal records are avilable in regard to past operation of the dam, nor of surcharge encroachments and flows through the spillway. U.S.G.S. Water-Supply Paper 798, The Floods of March 1936, reports that the maximum discharge for that flood at a point about 2.3 mi. downstream of the dam was 3,570 cfs on March 19, 1936. The drainage area above point of recorded discharge is 57 sq. mi., compared with a drainage area above Linwood Pond Dam of 50.4 sq. mi. A Worcester County Inventory Sheet for the dam reports that the 1938 Flood topped the dam by 0.5 ft. An inspection Report made by the Worcester County Engineer dated October 19, 1938 states, "apparently the flood topped the embankment by a small amount (5 to 6 in.)". Another County Dam Inspection Report dated October 6, 1961 states, "Repaired after 1955 Flood", though there is no record of the flood stage.

5.4 Test Flood Analysis

Hydrologic and hydraulic characteristics of Linwood Pond Dam and drainage area were evaluated in accordance with the criteria given in Recommended Guidelines for Safety Inspection of Dams. For determining surface areas and surcharge capacities, planimetered areas were taken from contours delineated on U.S.G.S. 1:24,000 and 1:25,000 scale maps. As indicated in Section 1.2, paragraphs c and d, Linwood Pond Dam is classified as small in size and has a high hazard potential. The recommended range of test floods for hydraulic evaluation of such a dam is between ½ PMF and a full PMF. Because of the relatively small amount of storage in Linwood Pond and the available valley storage below the dam in Whitin Pond and Caprons Pond, a ½ PMF was selected as the test flood most appropriate for evaluation of the dam.

The NED March 1978 Preliminary Guidance Memorandum for Estimating Probable Discharges was used for estimating the probable maximum flood peak flow rate. A point was chosen half way between the NED's Rolling Terrain Curve and the Flat and Coastal Curve to yielding a PMF discharge of 700 cfs per sq. mi. For the test flood the value was then divided by 2, arriving at a CSM of about 350 and a discharge for the drainage area of 17,600 cfs. Because of the high discharge and low storage capability of the impoundment above the dam and inflow is approximately equal to outflow, a test flood routing was not performed.

A discharge curve for the dam was computed (see Sheets D-6 and D-7). The low level outlet gate was assumed closed when computing the curve. With the reservoir to the top of the dam (elevation 270.5) the spillway can release about 3,550 cfs or about 20 percent of the test flood outflow. The overflow portion of the spillway will not pass the test flood without overtopping the earth embankments by about 3.4 ft.

5.5 Dam Failure Analysis

A breach owing to structural failure of the dam is a possibility. For this analysis a breach was assumed with the water level at the top of the earth embankments. The "rule of thumb" method suggested in the NED March 1978 Guidance Report was used for the breach analysis. With a breach width of about 40 percent of the earth embankments or about 230 ft., a sudden surge of about 28,200 cfs would be realized in addition to a flow of 3,500 cfs from the spillway, giving a total discharge of 31,700 cfs (see Sheets D-9 thru D-12, Appendix D).

The impact area for failure of the dike is the same as for the dam. Immediately below Linwood Pond Dam there is a mill complex located on the left bank of the Mumford River. A breach of the dam could cause severe flooding in and around the mill complex. About 4,200 ft. below Linwood Pond Dam, the Mumford River is impounded by a dam which forms Whitin Pond. It is estimated that a breach would cause overtopping of this dam and that the stage of the River would be about 5 ft. higher than that which would be expected from the spillway discharge just prior to failure. The estimated flow in this area would be about 19,900 cfs and two houses in the vicinity of the dam would sustain heavy damage. About 2.2 miles below Linwood Pond Dam is the Caprons Pond Dam, another impoundment of the Mumford River. Here it is estimated that the discharge would be about 9,400 cfs and that the stage over the dam would be about 3 ft. higher than the stage caused by the spillway discharge through Linwood Pond Dam just prior to failure. Three commercial buildings containing shops and stores would sustain flood damage in this area. In the next reach beyond Caprons Pond Dam the river channel is narrow and little valley storage is available. It is estimated that the river stage in this location would rise about 6 ft. because of the breach and that a mill complex in close proximity to the river would sustain significant damage. It is estimated that in all the damage areas the depth of flooding of structures due to the breach would increase from about a 1 ft. depth just prior to failure to a depth of from 4 to 6 ft. after failure of the dam. About 0.5 mile below this point the Mumford River joins the Blackstone River, where the flood surge due to the breach should be significantly reduced.

In summary, a breach of Linwood Pond Dam could cause the flooding of two mill complexes, two houses, and three commercial buildings containing shops and stores, with the possibility of the loss of more than a few lives. The area of potential flooding is shown on Sheet D-13, Appendix D.

SECTION 6 - EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observations

There are no design calculations, as-built drawings or other data which would permit the preparation of structural stability computations. The dam and dikes are now stable and are in fair condition. Deficiencies described below and in Section 7 should be corrected.

The field inspection revealed the following:

(1) Seepage at the downstream toe of the right embankment and at the gravel pit beyond the reservoir rim.

(2) Need for repointing of mortar in the joints of the rubble masonry spillway training walls.

(3) Minor erosion on the upstream slope of the left embankment and downstream slope of the right embankment.

(4) Brush and tree growth on the right embankment and on the Linwood Avenue Dike.

(5) The condition of the low level outlet is unknown.

6.2 Design and Construction Data

No plan or calculations of value to a stability assessment are available.

6.3 Post-Construction Changes

There are no records of any major post-construction changes made to the dam, dikes or spillway that are of significance to the stability of the facility. However, there has been a recent gravel pit operation beyond the right abutment of the dam and along the right reservoir rim. The effect of the gravel pit on the integrity of the right reservoir rim needs to be fully addressed.

6.4 Seismic Stability

The dam is located in Seismic Zone No. 2 and in accordance with recommended Phase I guidelines, does not warrant seismic analysis.

SECTION 7
ASSESSMENT, RECOMMENDATIONS & REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. On the basis of the Phase I visual examination, Linwood Pond Dam and Dike appear to be in fair condition. The deficiencies revealed indicate that a further investigation should be carried out and that some remedial work is needed. The major concerns with the overall integrity of the dam are as follows:

(1) The spillway will only pass about 20 percent of the test flood without overtopping the embankments.

(2) A zone of seepage at the downstream toe of the right embankment.

(3) A zone of seepage in the mined out gravel pit near the right embankment.

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

c. Urgency. The recommendations and remedial measures enumerated below should be implemented by the owner within one year after receipt of this Phase I Inspection Report.

7.2 Recommendations

It is recommended that the owner should retain the services of a registered professional engineer experienced in the design of earth dams to make investigations and studies of the following, and, if proved necessary, to design appropriate remedial works:

(1) Make a thorough study of the hydrology of the drainage basin and evaluate further the potential for overtopping and the adequacy of the spillway.

(2) Inspect the spillway during a period of low flow or no flow conditions.

(3) Study and monitor the seepage emanating from the right reservoir rim into the abandoned gravel pit to the right of the dam.

(4) Study the seepage emanating from the right embankment.

(5) Investigate the structural integrity of the right reservoir rim.

(6) Removal of trees and heavy brush growth including their root systems from the upstream slope of the Linwood Avenue Dike, backfill with a suitable material and inspect the condition of the slope.

(7) Removal of trees and brush growth from both the upstream and downstream slopes of the embankment to the right of the spillway and backfill with suitable material.

(8) Determine the need to relocate the two pressure fire hydrants located on the dam.

7.3 Remedial Measures

a. Operating and Maintenance Procedures

(1) Repair and repoint the mortar joints in the left and right training walls of the spillway, including resetting dislodged capstones.

(2) Repair erosion on the upstream slope of the left embankment adjacent to the low level outlet and the left spillway training wall and on the downstream slope of the right embankment near the right training wall with suitable compacted soil, and riprap if necessary.

(3) Develop a formal surveillance and downstream emergency warning plan, including round-the-clock monitoring during periods of heavy precipitation. Such monitoring should include seepage through the right reservoir rim.

(4) Institute procedures for an annual periodic technical inspection of the dam and appurtenant structures including operation of the low level outlet and the condition of the concrete plug in the abandoned outlet conduit.

(5) Remove debris from spillway channel.

(6) Implement a regular periodic maintenance program.

7.4 Alternatives

The only practical alternative would be to remove the dam under the direction of a registered professional engineer with due consideration of environmental effects.

APPENDIX A

INSPECTION CHECKLIST

VISUAL INSPECTION CHECKLIST
PARTY ORGANIZATION

PROJECT LINWOOD POND DAM DATE 17 April 1980

OWNER Lusignan Corporation TIME 2:00 P.M.

WEATHER Fine

W.S. ELEV. 266.6 U.S. NA DN.S.

INSPECTION PARTY

A/E REPRESENTATIVES	OWNER'S REPRESENTATIVES
1. Peter B. Dyson	1. Paul Lusignan
2. Pasquale E. Corsetti	2.
3. Roger F. Berry	3.
4. Carl J. Hoffman	4.
5. William S. Zoino	5.

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Hydrologic	Roger F. Berry	LBA
2.	Hydraulics/Structures	Carl J. Hoffman	LBA
3.	Soils/Geology	William S. Zoino	GZA
4.	General Features	Peter B. Dyson	LBA
5.	General Features	Pasquale E. Corsetti	LBA
6.			
7.			
8.			
9.			
10.			

LBA - Louis Berger & Associates, Inc.
GZA - Goldberg-Zoino & Associates, Inc.

PERIODIC INSPECTION CHECKLIST

PROJECT LINWOOD POND DAM DATE 17 April 1980

PROJECT FEATURE Earth Embankment NAME

DISCIPLINE Soils/Geology NAME William S. Zoino

AREA EVALUATED	CONDITIONS
DAM EMBANKMENT	
Crest Elevation	270.5
Current Pool Elevation	266.6
Maximum Impoundment to Date	Unknown
Surface Cracks	None
Pavement Condition	N/A
Movement or Settlement of Crest	None
Lateral Movement	None
Vertical Alginment	Good
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Right Abutment: Seepage into gravel pit, erosion on upstream slope near low level outlet and on both slopes right of right training wall.
Indications of Movement of Structural Items on Slopes	None
Trespassing on Slopes	Tree growth on both slopes of right embankment.
Sloughing or Erosion of Slopes or Abutments	Erosion on upstream slope near low level outlet and on both slopes right of right training wall.
Rock Slope Protection - Riprap Failures	Small size rock cobbles on upstream face - no failures.
Unusual Movement or Cracking at or near Toes	None visible
Unusual Embankment or Downstream Seepage	50 ft. x 10 ft. area along toe of downstream slope of right embankment about 50 ft. right of right training wall is wet.
Piping or Boils	Seeps appear clear
Foundation Drainage Features	None
Toe Drains	None
Instrumentation System	None

PERIODIC INSPECTION CHECKLIST

PROJECT LINWOOD POND DAM DATE 17 April 1980

PROJECT FEATURE Linwood Avenue Dike NAME

DISCIPLINE Soils/Geology NAME William S. Zoino

AREA EVALUATED	CONDITIONS
DIKE EMBANKMENT	
Crest Elevation	Varies 270.8 to 271.1
Current Pool Elevation	266.6
Maximum Impoundment to Date	Unknown
Surface Cracks	None
Pavement Condition	Good
Movement or Settlement of Crest	None
Lateral Movement	None
Vertical Alignment	Good
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Abandoned gate structure in poor condition.
Indications of Movement of Structural Items on Slopes	Heavy brush and tree growth on upstream slope
Trespassing on Slopes	N/A
Sloughing or Erosion of Slopes or Abutments	None
Rock Slop Protection - Riprap Failures	Upstream slope not visible due to heavy brush and tree growth.
Unusual Movement or Cracking at or near Toes	None
Unusual Embankment or Downstream Seepage	None evident
Piping or Boils	None evident
Foundation Drainage Features	None evident
Toe Drains	None evident
Instrumentation System	None evident

PERIODIC INSPECTION CHECKLIST

PROJECT LINWOOD POND DAM DATE 17 April 1980

PROJECT FEATURE Low Level Outlet NAME

DISCIPLINE Hydraulics/Structures NAME Carl J. Hoffman

AREA EVALUATED	CONDITIONS
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	
General Condition of Concrete	Closed Masonry Structure
Rust or Staining	N/A
Spalling	N/A
Erosion or Cavitation	N/A
Visible Reinforcing	N/A
Any Seepage or Efflorescence	N/A
Condition at Joints	Not observed
Drain Holes	N/A
Channel	Outlets in left training wall
Loose Rock or Trees Overhanging Channel	Channel enclosed
Condition of Discharge Channel	N/A

PERIODIC INSPECTION CHECKLIST

PROJECT LINWOOD POND DAM DATE 17 April 1980

PROJECT FEATURE Spillway NAME

DISCIPLINE Hydraulics/Structures NAME Carl J. Hoffman

AREA EVALUATED	CONDITIONS
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	Man-made pond
General Condition	N/A
Loose Rock Overhanging Channel	N/A
Trees Overhanging Channel	N/A
Floor of Approach Channel	N/A
b. Weir and Training Walls	
General Condition of Concrete	Timber weir sill, appeared good. Training walls constructed of stone masonry.
Rust or Staining	N/A
Spalling	N/A
Any Visible Reinforcing	N/A
Any Seepage or Efflorescence	N/A
Drain Holes	None observed
c. Discharge Channel	
General Condition	Fair
Loose Rock Overhanging Channel	No
Trees Overhanging Channel	No
Floor of Channel	Loose boulders and debris
Other Obstructions	None

Mortar missing from rubble masonry spillway training walls.

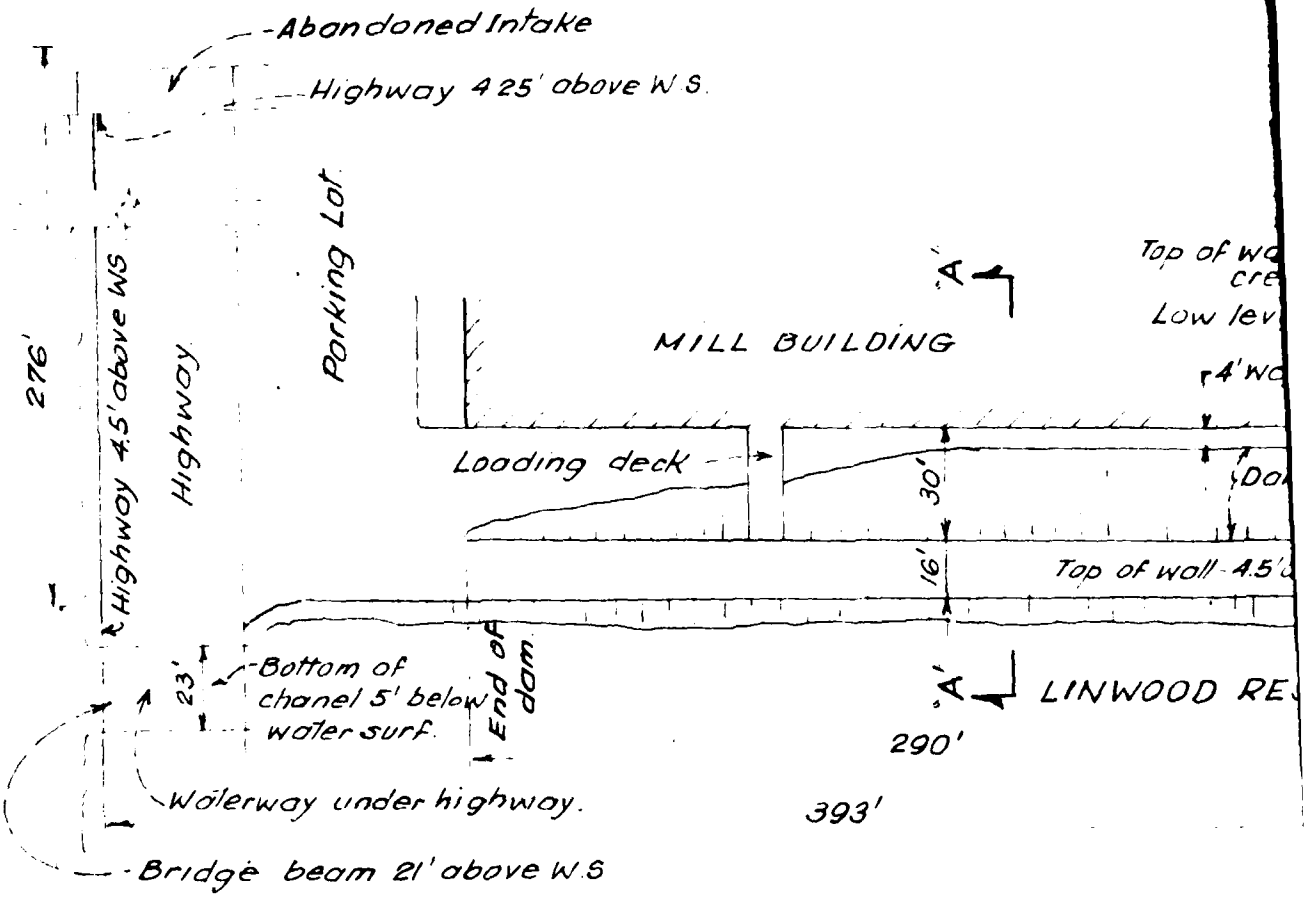
PERIODIC INSPECTION CHECKLIST

PROJECT: LINWOOD POND DAM DATE: 17 April 1980

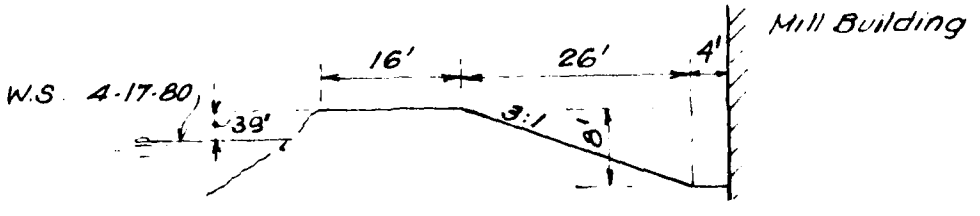
AREA EVALUATED	CONDITIONS
Outlet Works - Intake Channel and Intake Structure	N/A
Outlet Works - Control Tower	N/A
Outlet Works - Transition and Conduit	N/A
Outlet Works - Service Bridge	N/A

Appendix B

Engineering Data



PLAN



Spwy Crest
El. 266.0

Timber apro

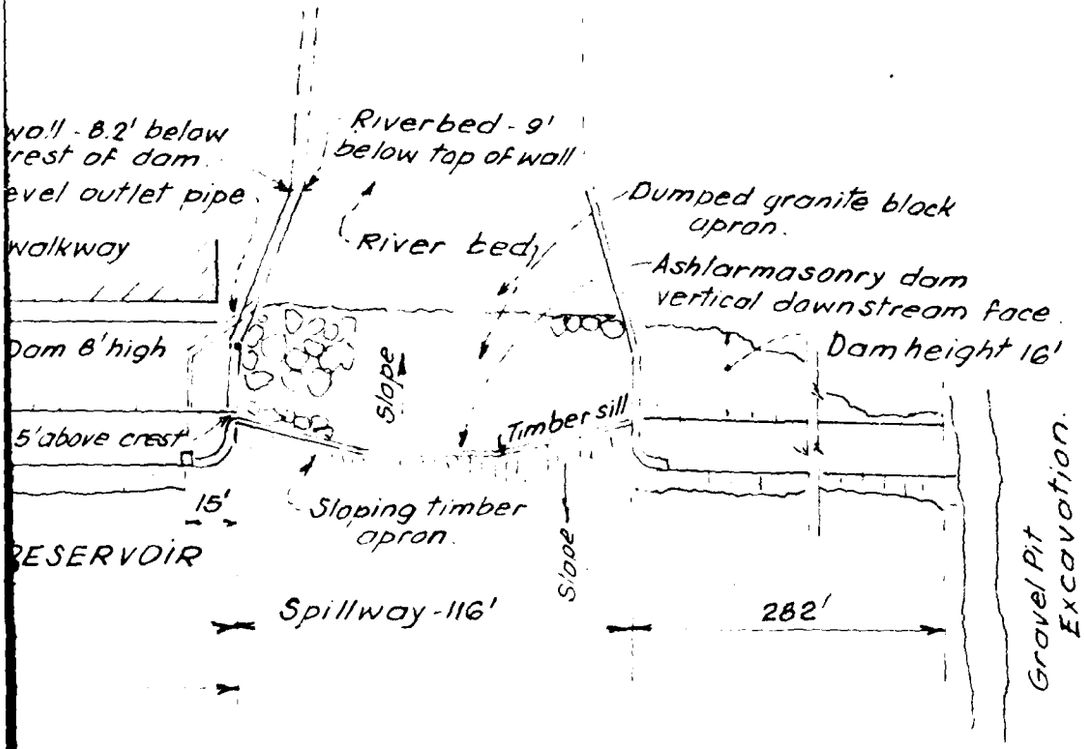
Dry Ashlar

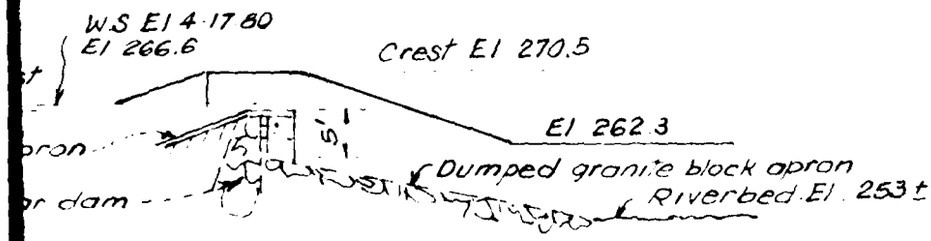
SECTION A-A

S

LINWOOD POND

2





SECTION THRU SPILLWAY

DAM

Tel. (617) 234-0251

Lusignan Realty Trust

LINWOOD BUILDING
666 LINWOOD AVE.
LINWOOD, MASSACHUSETTS 01525

March 20, 1974

Department of Public Works
403 Belmont St.
Worcester, Ma. 01604

Attention: Mr. John J. Lyon

Dear Mr. Lyon:

We are the new owners of the building located at 666 Linwood Avenue in Linwood, Mass., formerly owned by the Stylon Corporation and the Whitin Machine Works. The last plotting of this property was completed in December 1962 and is recorded in the Plan Book 137 - Plan 74 entitled Raytheon Mfg., Co., Linwood Mills etc.

We request the advice and authority of your office to make changes which are necessary for the present operation of this building and concerns the water known as Linwood Pond which supplied the source of power at one time.

It is fairly imperative to the effecient use of this building that the water running directly underneath and through our property be eliminated. We are equipped to do this, however it will mean the lowering of the pond very temporaily to close the gates supplying the water.

Although this is not a large project we will not proceed until advised as the local offices suggested our inquiry from yourself.

Thanking you for your attention to this matter, we are,

Very truly yours,

LUSIGNAN REALTY TRUST

Paul Lusignan

PL:bd

The Commonwealth of Massachusetts

Department of Public Works

DISTRICT #3 OFFICE
403 BELMONT STREET, WORCESTER 01604

April 9, 1974

Malcolm E. Graf
Associate Commissioner
Division of Waterways
100 Nashua Street
Boston, Massachusetts 02114

RE: Lusignan Realty Trust

Dear Sir:

In response to the attached letter District Dams and Reservoir Engineer, Thomas Powers visited the Lusignan Textile facility located in the Linwood Building at 666 Linwood Avenue, Linwood (Northbridge), Massachusetts on Monday April 1, 1974.

At that time Mr. Paul Lusignan told Mr. Powers, that in order to utilize the building more fully he wished to close permanently the inlet to the old mill head race, shown in red on the attached plan, thereby cutting off the flow of water from the pond through the building.

On site inspection by Mr. Powers revealed the following pertinent facts:

1. The head race has been buried by erosion and eutrification to within one foot more or less of the current water level in the pond.

2. At present water is seeping through and/or around the gate flowing under the road and through the building into the tail race. All seepage through the gate is carried in an 8" - 10" pipe which Mr. Lusignan reports flows full at all times.

3. There is an 10' x 8' (approx.) concrete box culvert (see attached plan) which acts as an equalizer between the two sections of the pond.

B-3

RE: Lusignan Realty Trust

4. The water level in both sections of the pond is controlled by gates on the dam behind the Linwood Building and on the property of the Lusignan Realty Trust (See Plan).

In view of the fact that the head race gate presently affords no effective additional outlet capacity and that the existing box culvert provides ample waterway area to maintain equal water levels in both sections of the pond, it is my opinion that the proposed project would cause no hazard to the public safety or to private property.

Very truly yours,

JOHN J. LYONS, P.E.
DISTRICT HIGHWAY ENGINEER

TP/mej
Enclosure

C-TP
ROR

April 17, 1974

Lucignan Realty Trust
Linwood Building
666 Linwood Avenue
Linwood, Massachusetts 01525

Attention: Paul Lucignan

RE: Linwood Pond

Dear Sir:

Authorization of the changes proposed in your letter dated March 27, 1974 is not within the jurisdiction of this Department but permission should be obtained from the 1 authorities before any work is begun.

Very truly yours,

[illegible]

CP/mcj

1-CP
[illegible]
[illegible]

Dam No. 6-14-216-03

June 4, 1974

Mr. James Stolle
Northbridge Conservation Commission
6 Overlook Street
Whitinsville, Massachusetts 01588

Dear Mr. Stolle:

Reference is made to your telephone conversation with Mr. John Piaseczny of this office regarding the temporary drawdown of Linwood Pond by the Lusignan Realty Trust.

Enclosed are copies of the correspondence you've requested pertaining to this matter.

Very truly yours,

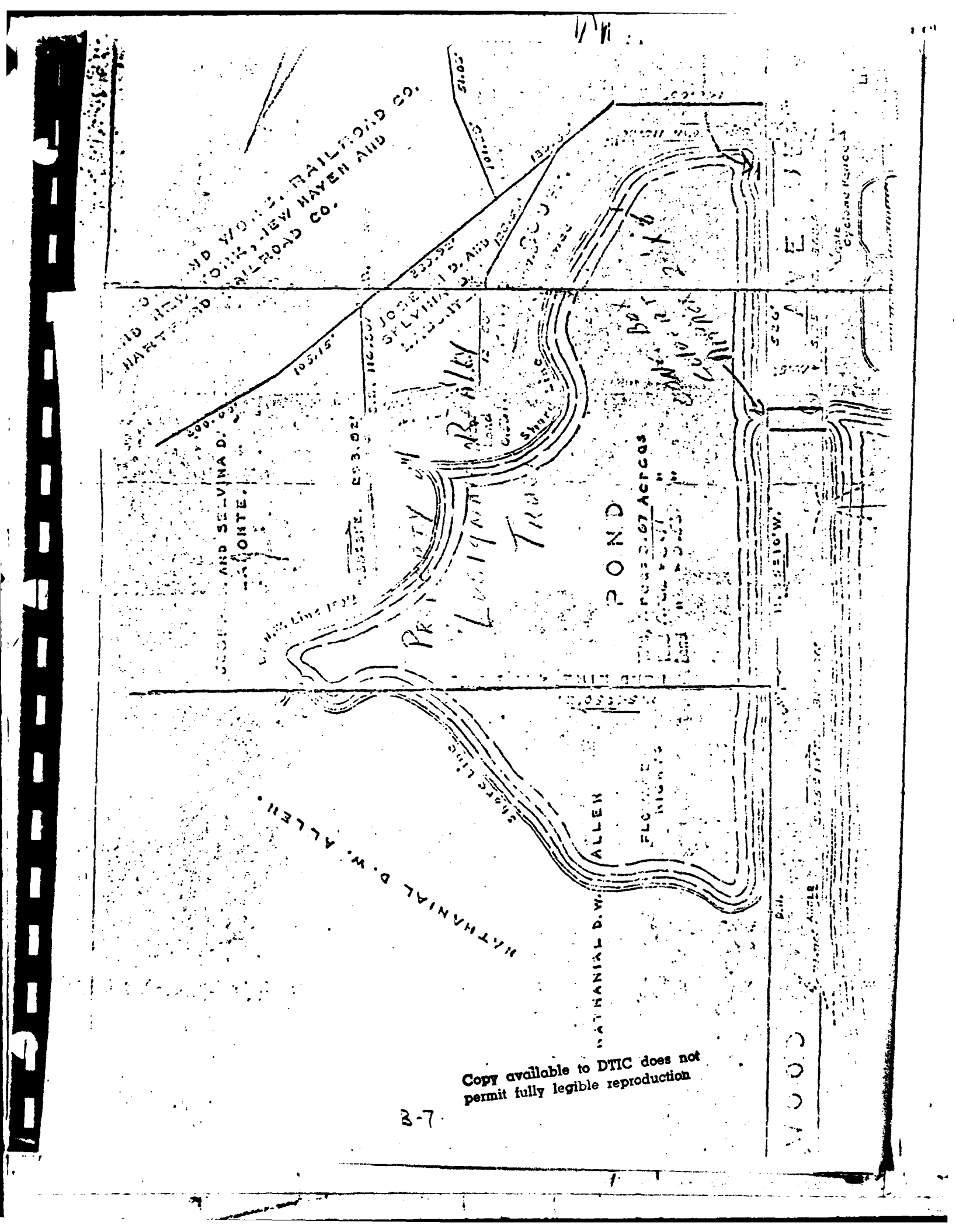
F. C. Schwelm

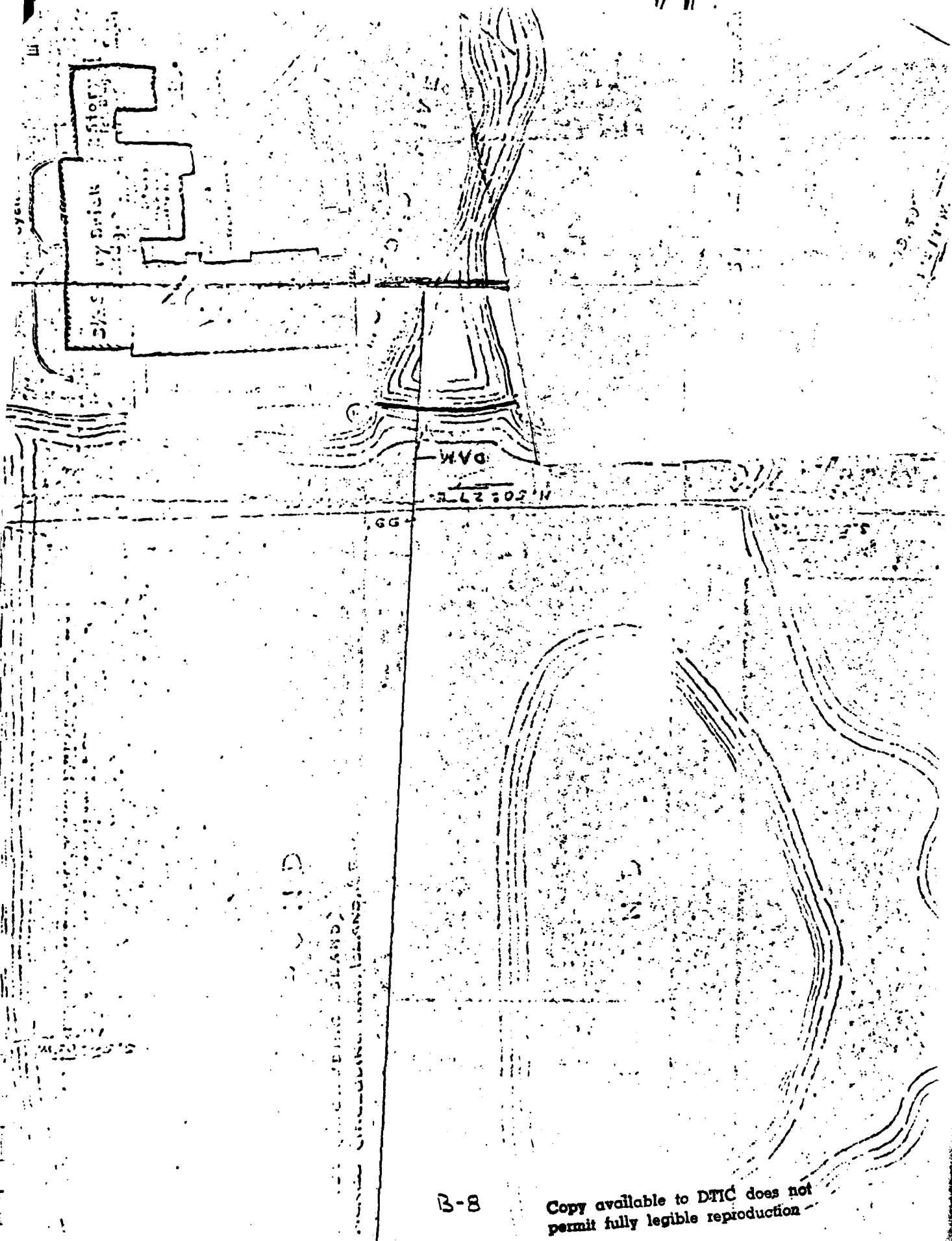
FRED. C. SCHWELM, P.E.
Deputy Chief Engineer

JHP
JHP:jmp
Enclosed:

Northbridge No. 3-14-216-03

B-6


POND
NATHANIAL D.W. ALLEN
Copy available to DTIC does not permit fully legible reproduction



(17) TOWN OR CITY Northbridge DECREE NO. PLAN NO. DAM NO. 35-03

LOCATION Linwood Pond C. C. DOCKET NO.

DESCRIPTION OF DAM

Type Stone spillway & forebay - earth emb. [illegible]
Length = 630.'
Height 10.' to crest = 5.5
Thickness top = 16.' crest abt El. top Abt = 104.5
" bottom spillway 50'-60'
Downstream Slope Spillway 4:5 ver. abt 1½:1 stone apron
Upstream Riprap " plank 1' in 10'.
Length of Spillway El. crest = 100.0 Length = Abt 115.'
Size of Gates waste = 3'x3' El. 94.5' width crest 16'
Location of Gates waste North of Spillway.
Flashboards used Yes
Width Flashboards or Gates 3'-6"
Dam designed by
" constructed by G. Blanchard
Year constructed 1865-1907 & [illegible]

GENERAL REMARKS

[redacted]
Wheels - 2 Holyoke pipe 48 & 33" dia
Head = 12.' Rated H.P. = 225-250.
Sea Level crest dam = 266.0
1938 Flood = 0.5 over Embankment
1936 " El. 269.7

Owned by Whitin Machine Works

DESCRIPTION OF RESERVOIR & WATERSHED

Name of Main Stream Mumford River
" " any other Streams
Length of Watershed
Width " "
Is Watershed Cultivated
Percent in Forests
Steepness of Slope Flat - Rolling country each side
Kind of Soil Hard pan
No. of Acres in Watershed 31,744. 49.6 sq.m.
" " " " Reservoir 50.7
Length of Reservoir
Width " "
Max Flow Cu. Ft. per Sec.
Head or Flashboards-Low Water
" " " -High "

GENERAL REMARKS

Inspected: March 3, 1924 - L.O. Marden
" July 8, 1927 " "
" Oct. 29, 1928 " "
" " 18, 1929 " "
" June 19, 1933 " "
" Oct. 19, 1938 L.H. Spofford
Mass. vol. 418-p. 79 Mar. 27, 1939 B.F. St. John
" Dec. 14, 1940 K.M. Finlayson
Jan 8 1953 Delbert Barnes & L.H. Spofford

COUNTY OF WORCESTER MASSACHUSETTS

COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs.

Inspected by L.O.Marden ✓ Date 3-27-24 7-8-27 ✓ Dam No. 35-03 ✓

Town Northbridge ✓ Location W. Linwood ✓

Owner Whitin Bros. Inc ✓ Use Power

Material and Type

Dam Designed by Constructed by G.Blanchard ✓ Year 1865 ✓

SPILLWAY LENGTH 110-120+- ✓

El. top Abutment 104.5 ✓ El. Crest 100 ✓ El. Apron El. Streambed 94.5 ✓

Width top Abutment 16 ✓ Width top Crest 16 ✓ Width bottom Spillway 50-60 ✓

Width Flashboards carried 3.5 ✓ Kind Flashboards

El. Flowline Cleanout Pipe Size and Kind Cleanout Pipe

Kind of Foundation under Spillway

Condition

EMBANKMENT LENGTH 630+- ✓

El. Top 104.5 El. Natural Ground 94.5 ✓ Width Top 16 ✓

Width of Bottom 50-60 ✓ Upstream Slope Downstream Slope

Kind of Corewall Riprap

Material in Embankment on hardpan ✓ Foundation

Condition good ✓

GATES cleanout ✓ Location cleanout north spillway ✓

Size 3x3+- ✓ Kind El. Flowline

Condition

WHEEL 2 ✓ Kind Holyoke ✓ Size 48-33 ✓ Rated H. P. 225-250 ✓

Location Ave. Head 12 ✓

Evidence of Leaks in Structure

Recent Repairs and Date 1907 new plank and beams ✓

Topography of Country below Dam Flat- slightly rolling on eah side stream bed

Nature of Buildings and Roads below Dam none immediatly below ✓

Number Acres in Pond Drainage Area in Square Miles

Discharge in Second Feet per Square Mile

Estimated Storage Million Cubic Feet

COUNTY OF WORCESTER MASSACHUSETTS

COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs.

Inspected by L.O.Marden Date Oct. 10, 1929 Oct.29,1928 Dam No. 35-03.

Town Northbridge Location Linwood.

Owner Whitin Bros., Inc. Use

Material and Type

Dam Designed by Constructed by Year

SPILLWAY

El. top Abutment El. Crest El. Apron El. Streambed

Width top Abutment Width top Crest Width bottom Spillway

Width Flashboards carried Kind Flashboards

El. Flowline Cleanout Pipe Size and Kind Cleanout Pipe

Kind of Foundation under Spillway

Condition good.

EMBANKMENT

El. Top El. Natural Ground Width Top

Width of Bottom Upstream Slope Downstream Slope

Kind of Corewall Riprap

Material in Embankment Foundation

Condition good.

GATES Location

Size Kind El. Flowline

Condition good.

WHEEL Kind Size Rated H. P.

Location Ave. Head

Evidence of Leaks in Structure none

Recent Repairs and Date none

Topography of Country below Dam

Nature of Buildings and Roads below Dam

Number Acres in Pond Drainage Area in Square Miles

Discharge in Second Feet per Square Mile

Estimated Storage Million Cubic Feet

B-12

COUNTY OF WORCESTER MASSACHUSETTS

COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs.

Inspected by L.O.K. and Mr. Liberty Date June 19,1933 Dam No. 35-03

Town Northbridge Location Whitin Station

Owner Whitin Bros. Inc. & Saunders Cotton Mill. Use

Material and Type

Dam Designed by Constructed by Year

SPILLWAY—Length Feet. Depth Feet

El. top Abutment El. Crest El. Apron El. Streambed

Width top Abutment Width top Crest Width bottom Spillway

Width Flashboards carried Kind Flashboards

El. Flowline Cleanout Pipe Size and Kind Cleanout Pipe

Kind of Foundation under Spillway

Condition O.K. South abutment should have joints motared.

EMBANKMENT—Length overall Feet

El. Top El. Natural Ground Width Top

Width of Bottom Upstream Slope Downstream Slope

Kind of Corewall Riprap

Material in Embankment Foundation

Condition South embankment should have brush cut and roots grubbed.

GATES O.K. Location

Size Kind El. Flowline

Condition

WHEEL Kind Size Rated H. P.

Location Ave. Head

Evidence of Leaks in Structure None visible.

Recent Repairs and Date None.

Topography of Country below Dam

Nature of Buildings and Roads below Dam

Number of Acres in Pond Drainage Area in Square Miles

Discharge in Second Feet per Square Mile

Estimated Storage Million Cubic Feet

WORCESTER COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs

Inspected by L.H. Spofford Date 10-19-38 Dam No. 35-03

Town Northbridge Location

Owner Whitin Bros. Inc. Use Power

Earth embankment- 100±ft. x 4'6" cemented masonry side walls.

SPILLWAY Cut stone front wall with timber breast beam

El.top Abutment El.Crest El.Apron El.St.Bed

Width top Abut. Width top Crest Width bottom Sp.way

Width flashboards apparently about 6" flashboards were on, portions of these were Kind Flashboards carried away

El.Flowline Cleanout Pipe Size and Kind Pipe

Kind of Foundation under Spillway

Condition Good- apparently the flood topped the embankment by a small amount (5 or 6 in.)

EMBANKMENT

El.Top El.Natural Ground Width Top

Width of Bottom Upstream Slope Downstream Slope

Kind of Corewall Riprap

Material in Embankment Foundation

Condition Good condition - well sodded at east end and shows no damage from being topped. Some brush growing on top at west end. Mr. Liberty says this will be cut at once.

GATES 1 large gate operated by lead screw Location

Size Kind El.Flowline

Condition

Evidence of Leaks in Structure

Recent Repairs and Date

Number Acres in Pond Drainage Area in Sq.Miles

Discharge in Second Feet per Square Mile

Estimated Storage Million Cubic Feet

COUNTY OF WORCESTER MASSACHUSETTS
COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs.

Inspected by B.P.St.John Date 3-27-1939- Dam No. 35-03

Town Northbridge Location

Owner Use

Material and Type measured cross section spillway- Bk.119-P.79

Dam Designed by Constructed by Year

SPILLWAY

El. top Abutment El. Crest El. Apron El. Streambed

Width top Abutment Width top Crest Width bottom Spillway

Width Flashboards carried Kind Flashboards

El. Flowline Cleanout Pipe Size and Kind Cleanout Pipe

Kind of Foundation under Spillway

Condition

EMBANKMENT

El. Top El. Natural Ground Width Top

Width of Bottom Upstream Slope Downstream Slope

Kind of Corewall Riprap

Material in Embankment Foundation

Condition

GATES Location

Size Kind El. Flowline

Condition

WHEEL Kind Size Rated H. P.

Location Ave. Head

Evidence of Leaks in Structure

Recent Repairs and Date

Topography of Country below Dam

Nature of Buildings and Roads below Dam

Number Acres in Pond Drainage Area in Square Miles

Discharge in Second Feet per Square Mile

Estimated Storage Million Cubic Feet

WORCESTER COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs

Inspected by K.M.F Date 12-19-40 Dam No. 35-03

Town Northbridge Location Linwood

Owner Paul White Mfg Co Use

SPILLWAY

El.top abutment El.Crest El.Apron El.St.Bed

Width top Abut. Width top Crest Width bottom Sp.way

Width flashboards Kind Flashboards

El.Flowline Cleanout Pipe Size and Kind Pipe

Kind of Foundation under Spillway

Condition fr

EMBANKMENT

El. Top El.Natural Ground Width Top

Width of Borrom Upstream Slope Downstream Slope

Kind of Corewall Riprap

Material in Embankment Foundation

Condition fr

GATES Location

Size Kind El.Flowline

Condition fr

Evidence of Leaks in Structure

Recent Repairs and Date

Number Acres in Pond Drainage Area in Sq. Miles

Discharge in Second Feet per Square Mile

Estimated Storage Million Cubic Feet

WORCESTER COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs

Inspected by KMF Date 12-14-40 Dam No. 35-03A

Town Northbridge Location Whitinsville

Owner _____ Use _____

SPILLWAY

El. top abutment _____ El. Crest _____ El. Apron _____ El. St. Bed _____

Width top Abut. _____ Width top Crest _____ Width bottom Sp.way _____

Width flashboards _____ Kind Flashboards _____

El. Flowline Cleanout Pipe _____ Size and Kind Pipe _____

Kind of Foundation under Spillway _____

Condition fair

EMBANKMENT

El. Top _____ El. Natural Ground _____ Width Top _____

Width of Borrom _____ Upstream Slope _____ Downstream Slope _____

Kind of Corewall _____ Riprap _____

Material in Embankment _____ Foundation _____

Condition _____

GATES _____ Location _____

Size _____ Kind _____ El. Flowline _____

Condition _____

Evidence of Leaks in Structure _____

Recent Repairs and Date _____

Number Acres in Pond _____ Drainage Area in Sq. Miles _____

Discharge in Second Feet per Square Mile _____

Estimated Storage Million Cubic Feet _____

TOWN Whitinsville

LOCATION Below 03A

DAM NO. 35-03

STREAM

WORCESTER COUNTY ENGINEERING DEPARTMENT

WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

OWNED BY Whitin Machine Co PLACE USE Process

INSPECTED BY J H Agnew + Mr Barnes DATE 1/8/53

TYPE OF DAM Stone Apron CONDITION Good

SPILLWAY

FLASHBOARDS IN PLACE None RECENT REPAIRS None

CONDITION Good

REPAIRS NEEDED None

EMBANKMENT

RECENT REPAIRS None

CONDITION Good

REPAIRS NEEDED None

GATES

RECENT REPAIRS None

CONDITION Good (Rack + Pinion

REPAIRS NEEDED None

LEAKS

HOW SERIOUS

DATE

COUNTY ENGINEER

TOWN Whitinsville

LOCATION Below Rug Shop

DAM NO. 35-03 A

STREAM

WORCESTER COUNTY ENGINEERING DEPARTMENT

WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

OWNED BY Whitin Machine Co PLACE USE None

INSPECTED BY L H Apollow + M Brown 1/2/53

TYPE OF DAM Timber Breast wall. CONDITION

SPILLWAY

FLASHBOARDS IN PLACE None RECENT REPAIRS None

CONDITION Poor

REPAIRS NEEDED None

EMBANKMENT

RECENT REPAIRS None

CONDITION Good

REPAIRS NEEDED None

GATES

RECENT REPAIRS None

CONDITION

REPAIRS NEEDED

LEAKS

HOW SERIOUS

DATE

COUNTY ENGINEER

TOWN Northbridge DAM NO. 35-03

LOCATION _____ STREAM _____

WORCESTER COUNTY ENGINEERING DEPARTMENT

WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

OWNED BY _____ PLACE _____ USE _____

INSPECTED BY LHS, & LHS, DATE Sept. 15, 1955

TYPE OF DAM _____ CONDITION _____

SPILLWAY

FLASHBOARDS IN PLACE _____ RECENT REPAIRS _____

CONDITION OK

REPAIRS NEEDED _____

EMBANKMENT

RECENT REPAIRS _____

CONDITION Ok

REPAIRS NEEDED _____

GATES

RECENT REPAIRS _____

CONDITION OK

REPAIRS NEEDED _____

LEAKS

HOW SERIOUS _____

DATE _____

COUNTY ENGINEER

TOWN Northbridge DAM NO. 35-03A

LOCATION _____ STREAM _____

Current Dam

WORCESTER COUNTY ENGINEERING DEPARTMENT

WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

OWNED BY _____ PLACE _____ USE _____

INSPECTED BY LHS & LHS, DATE Sept. 15, 1955

TYPE OF DAM _____ CONDITION _____

SPILLWAY

FLASHBOARDS IN PLACE _____ RECENT REPAIRS _____

CONDITION OK -

REPAIRS NEEDED _____

EMBANKMENT

RECENT REPAIRS None

CONDITION _____

REPAIRS NEEDED _____

GATES

RECENT REPAIRS None

CONDITION _____

REPAIRS NEEDED _____

LEAKS

HOW SERIOUS _____

DATE _____

_____
COUNTY ENGINEER

TOWN Whitinsville DAM NO. 35-03 A

LOCATION Mumford River STREAM

just below Douglas Rd

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by W. M. Works Place Whitinsville Use

Inspected by P. B. Walker - P. Barnes Jan Date Oct. 6, 1961

Type of Dam Condition

SPILLWAY Old log dam

Flashboards in Place Recent Repairs

Condition not maintained - El. dam about 3o above Stream bed

Repairs Needed - Do not use - will not repair

EMBANKMENT

Recent Repairs —

Condition —

Repairs Needed —

GATES

Recent Repairs None - taken out

Condition

Repairs Needed

LEAKS

How Serious Dam removed

DATE: oct. 6 1961 L. O. Marder County Engineer

TOWN Northbridge DAM NO. 35-03

LOCATION _____ STREAM Linwood Mill Dam Mumford River

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by White Machine Works Place _____ Use _____

Inspected by B.P. Walker D. Bacon Jr. Date Oct. 6, 1961

Type of Dam _____ Condition Good

SPILLWAY Repaired after 1955 Flood

Flashboards in Place None Recent Repairs None

Condition Good

Repairs Needed _____

EMBANKMENT

Recent Repairs None

Condition Good - No leaks

Repairs Needed None

GATES

Recent Repairs None

Condition Good

Repairs Needed None

LEAKS

How Serious No leak

DATE: Oct 6, 1961

C.A. Marden
County Engineer

TOWN Northbridge DAM NO. 35-03

LOCATION Linwood - Mumford River STREAM

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

D A M I N S P E C T I O N R E P O R T

Owned by Whitin Machine Works Place Linwood Use

Inspected by L.O.M. L.R. Ball-Power Plant Chief Eng. Date April 5, 1962

Type of Dam Earth Emb. Condition Looks good

SPILLWAY

Flashboards in Place None Recent Repairs None

Condition visual inspection - looks good

Repairs Needed Steel downstream crest

EMBANKMENT

Recent Repairs None - No brush

Condition Good

Repairs Needed None

GATES

Recent Repairs None

Condition Good

Repairs Needed None

LEAKS

How Serious Not Serious

DATE: April 5, 1962 L.O. Marden County Engineer

TOWN Northbridge DAM NO. 35-03 A

LOCATION Ring Shop Dam STREAM

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by White Machine Co Place Whitinsville Use

Inspected by Dan Bacon & Ken Date 4-5-62

Type of Dam Condition

SPILLWAY

Flashboards in Place 3.0" Flash bd Recent Repairs

Condition ogee crest

Repairs Needed No repairs needed

EMBANKMENT

Recent Repairs

Condition

Repairs Needed

GATES

Recent Repairs

Condition

Repairs Needed

LEAKS

How Serious

DATE: County Engineer

TOWN *Northbridge* DAM NO. *35-03*

LOCATION *Linwood St* STREAM *Mumford River*

"Linwood Village" *"Linwood Pond"*

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by *Stymie Corporation* Place *Northbridge* Use *Mill Pond*

Inspected by *W.O.L.* Date *Jan. 25 1963*

Type of Dam *Earth and stone* Condition *Good*

SPILLWAY

Flashboards in Place *No boards* Recent Repairs ______

Condition *This stone spillway has a 12"x12" wood timber crest.*

Repairs Needed *- the downstream apron is made with heavy stone.*

EMBANKMENT

Recent Repairs ______

Condition *Good condition*

Repairs Needed ______

GATES

Recent Repairs *The gate located 35' westerly of the spillway is good.*

Condition *There is some floating debris near this gate.*

Repairs Needed *The 4 gates to the mill from a section of the [illegible] Linwood St - are inoperable. Gravel has been dumped at their inlets to sea[l] off [illegible]*

LEAKS

How Serious ______

DATE: ______ County Engineer

TOWN [illegible] DAM NO. 35-03

LOCATION [illegible] STREAM

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

D A M I N S P E C T I O N R E P O R T

Owned by Place Use

Inspected by [illegible] Date [illegible]

Type of Dam Condition

SPILLWAY

Flashboards in Place None Recent Repairs

Condition [illegible]

Repairs Needed [illegible]

EMBANKMENT

Recent Repairs

Condition

Repairs Needed

GATES

Recent Repairs

Condition

Repairs Needed

LEAKS

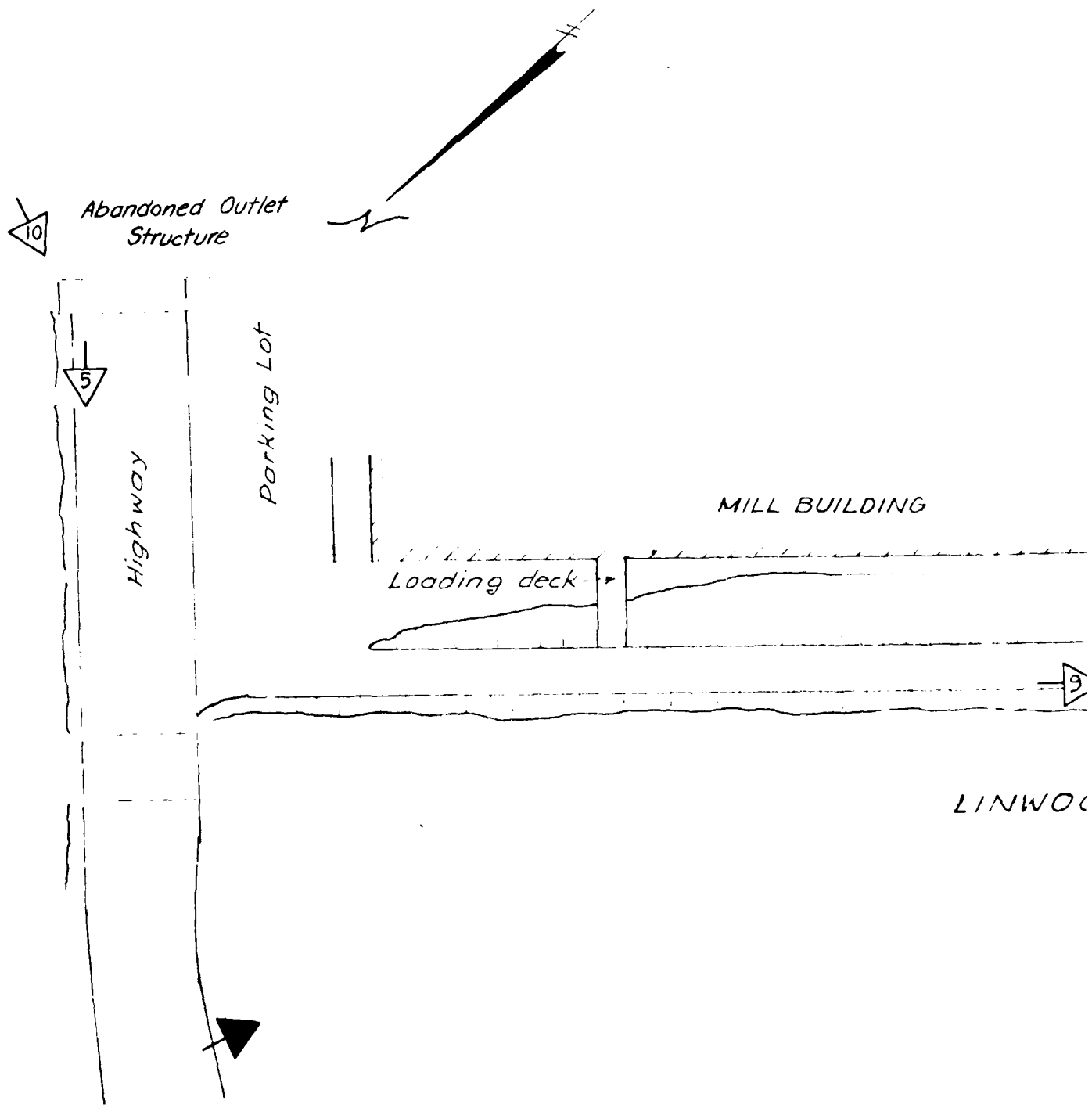
How Serious

DATE:

County Engineer

Appendix C

Photographs



LINWOOD POND

LOUIS BERGER & ASSOC., INC WESTFIELD, MASS. ARCHITECT - ENGINEER	US ARMY ENGINEER DIV NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LINWOOD POND DAM

2

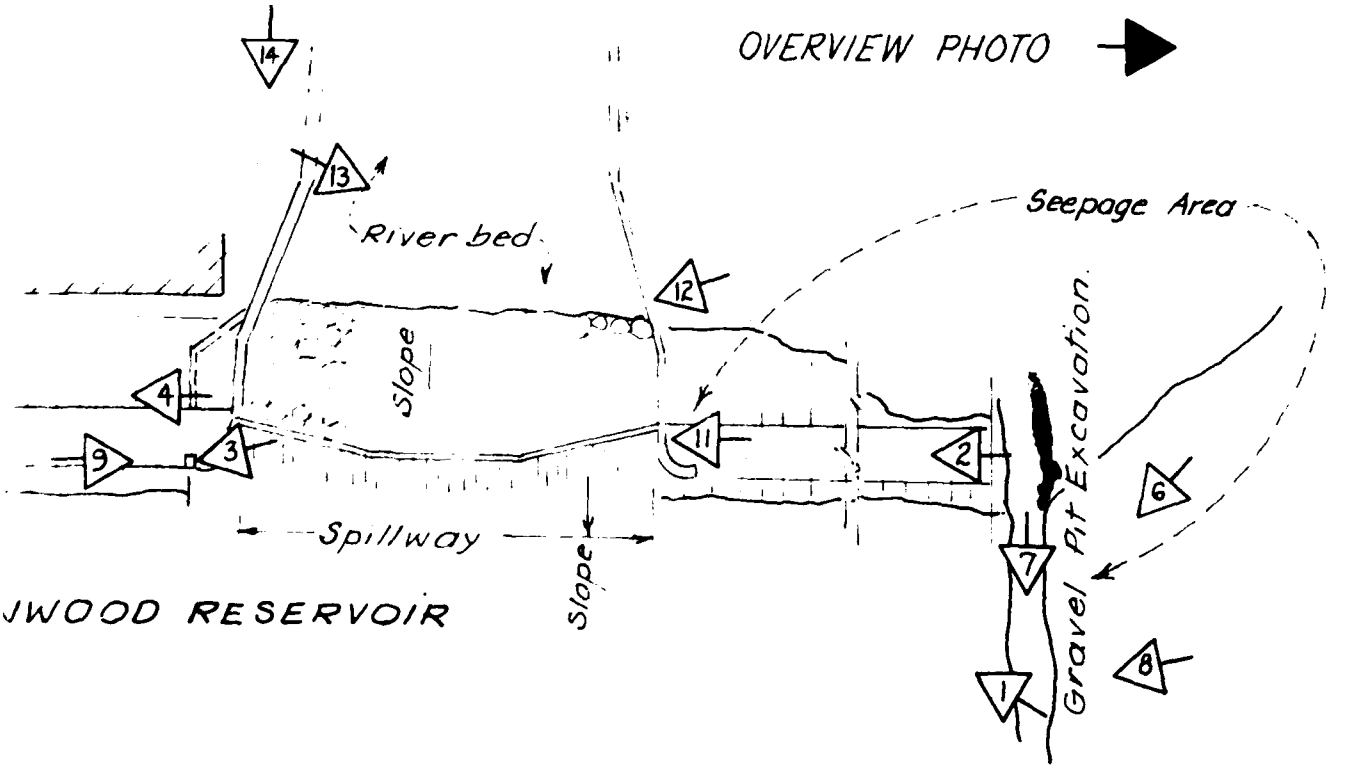
SKETCH PLAN SHOWING LOCATION & ORIENTATION OF PHOTOS

STATE -

			SCALE NONE SCALE
			DATE

APPENDIX 'C' PHOTOS →

OVERVIEW PHOTO →

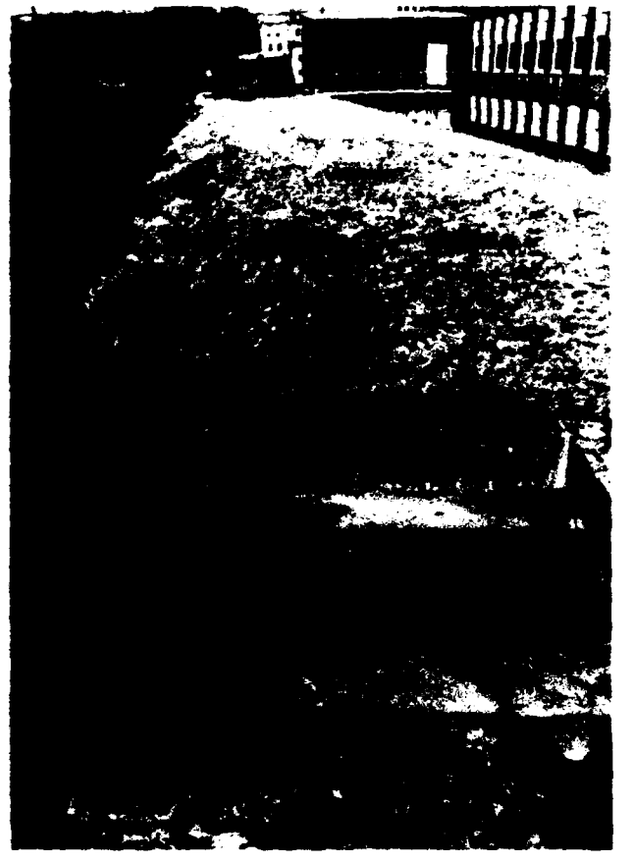


JWOOD RESERVOIR

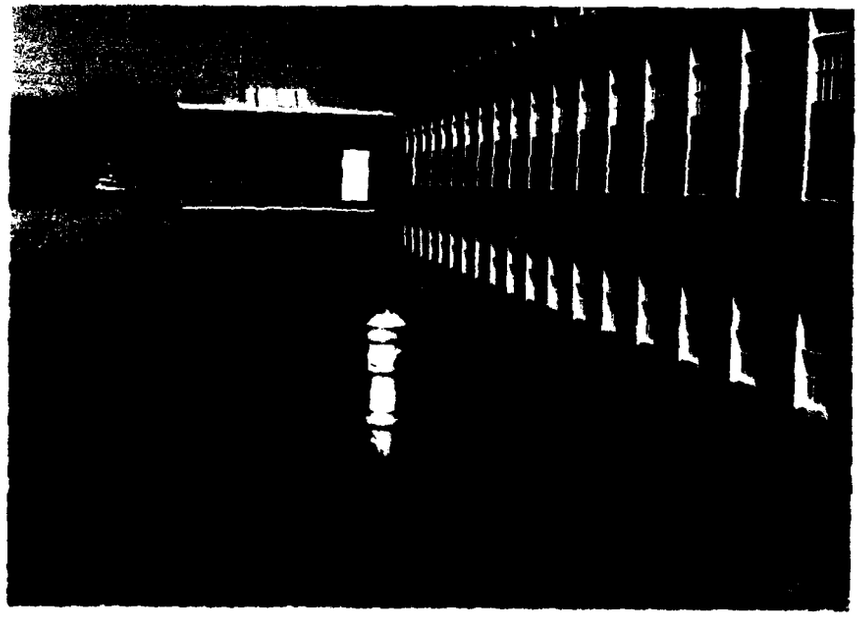
OND DAM

1. Mature trees on upstream slope of right embankment.

2. Crest and downstream slope of right embankment.

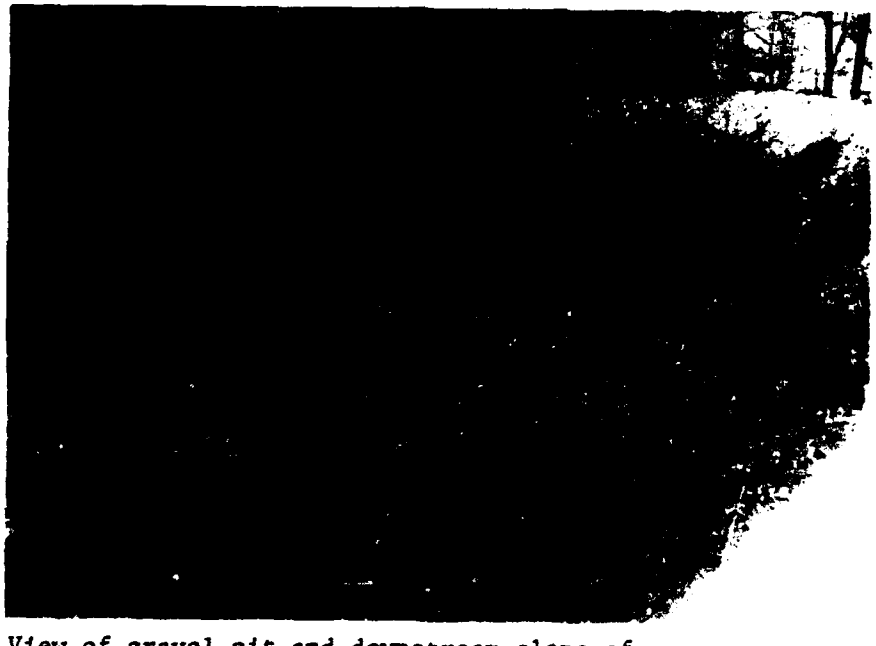


3. Upstream slope of left embankment and low level outlet control mechanism.



4. Downstream slope of left embankment.

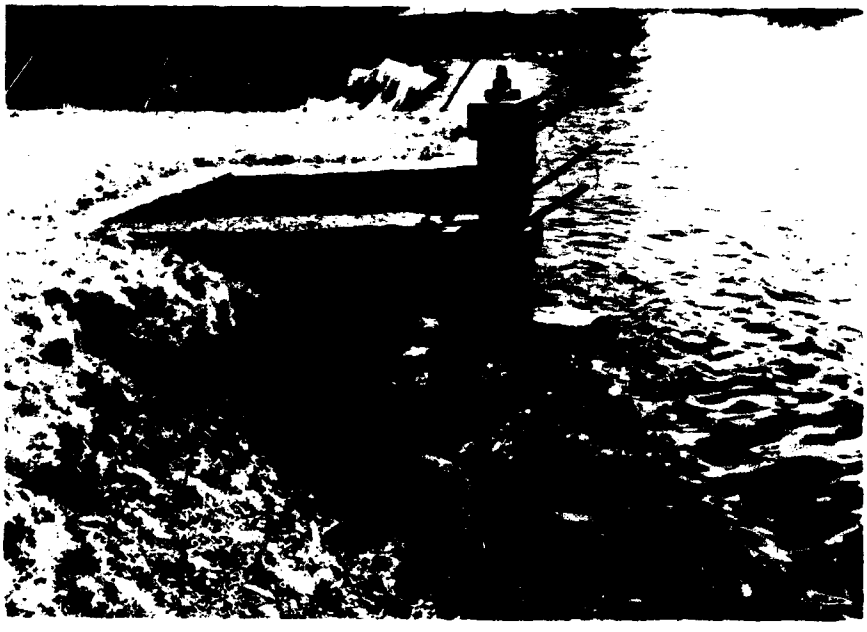
5. Crest and upstream slope of Linwood Avenue Dike.



6. View of gravel pit and downstream slope of right reservoir rim embankment.

7. Crest and downstream slope of right reservoir rim.

8. Seepage at downstream toe of right reservoir rim embankment.



9. Low level outlet control mechanism.

10. Abandoned outlet gate structure at Linwood Avenue Dike

11. View along spillway crest.

12. Left spillway training wall and low level outlet at downstream toe of spillway.

13. Right spillway training wall.

14. Debris immediately downstream of spillway crest.

Appendix D

Hydrologic and Hydraulic Computations

BY [illegible] DATE 3-27-80 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 1 OF

CHKD. BY DATE INSPECTION OF DAMS PROJECT W-198

SUBJECT LINWOOD [illegible] DAM H&H

[illegible] DRAINAGE AREA, UXBRIDGE QUAD 1:24,000

AREA #1	READ #2	34.74	READ #3	66.27	AVE 31.495
	" #1	3.28	" #2	34.74	
		31.46		31.53	
AREA #2	READ #2	118.59	READ #3	68.30	AVE 49.655
	" #1	68.99	" #2	18.59	
		49.60		49.71	
AREA #3	READ #2	133.72	READ #3	79.30	AVE 45.61
	" #1	88.08	" #2	33.72	
		45.64		45.58	
AREA #4	READ #2	73.30	READ #3	101.77	AVE 28.485
	" #1	44.80	" #2	73.30	
		28.50		28.47	

OXFORD QUAD 1:24,000

AREA #1	READ #2	44.37	READ #3	64.08	AVE 19.765
	" #1	24.55	" #2	44.37	
		19.82		19.71	
AREA #2	READ #2	70.68	READ #3	79.96	AVE 9.28
	" #1	61.37	" #2	70.68	
		9.31		9.25	

WORCHESTER SO 1:24,000

READING #2	42.65	READ #3	46.40	AVE 3.76
" #1	38.88	" #2	42.65	
	3.77		3.75	

BY RFF DATE 3-27-80 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 2 OF
CHKD. BY DATE INSPECTION OF DAMS PROJECT W-198
SUBJECT LINWOOD POND DAM H&H

DRAINAGE AREA GRAFTON 1" = 2000'

AREA #1	READ #2 113.93	READ #3 136.03	AVE 22.125	
	" #1 91.78	" #2 113.93		
	22.15	22.10		
AREA #2	READ #2 52.98	READ #3 81.04	#5 72.09	
	" #1 24.61	" #2 52.98	#4 43.97	
	28.37	28.06	28.22	

AVE 28.22

DRAINAGE AREA : 188.05 (0.1435) = 26.985
50.345 (0.1556) = 7.834
+ MANCHAUG POND D.A. 6.607
+ WHITIN RESERVOIR D.A. 8.931
50.357

DRAINAGE AREA = 50.36 SQ. MI = 32,228 ACRES

RESERVOIR SURFACE AREA, ELEV 266

READ #2	77.31	READ #3 77.88
" #1	76.82	" #2 77.31
	0.49	0.57

RESERVOIR AREA = 0.53 (91.83) = 48.7 ACRES

AREA @ ELEV 270

READ #2	79.04	READING #3 79.87
" #1	78.21	" #2 79.04
	0.83	0.83

AREA ELEV 270 = 0.83 (91.83) = 76.2 ACRES

BY RFB DATE 3-27-80 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 3 OF

CHKD. BY DATE INSPECTION OF DAMS PROJECT W-198

SUBJECT LINWOOD POND DAM

AREA @ ELEV 280

READ #2	84.73	READ #3	86.58	#4	88.40
" #1	82.58	" #1	84.73	#3	86.57
	2.15		1.85		1.83

AREA ELEV 280 = 1.84 (91.83) = 169 ACRES

BY RFB DATE 5-20-80 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 1 OF 1

CHKD. BY DATE INSPECTION OF DAMS PROJECT W-93

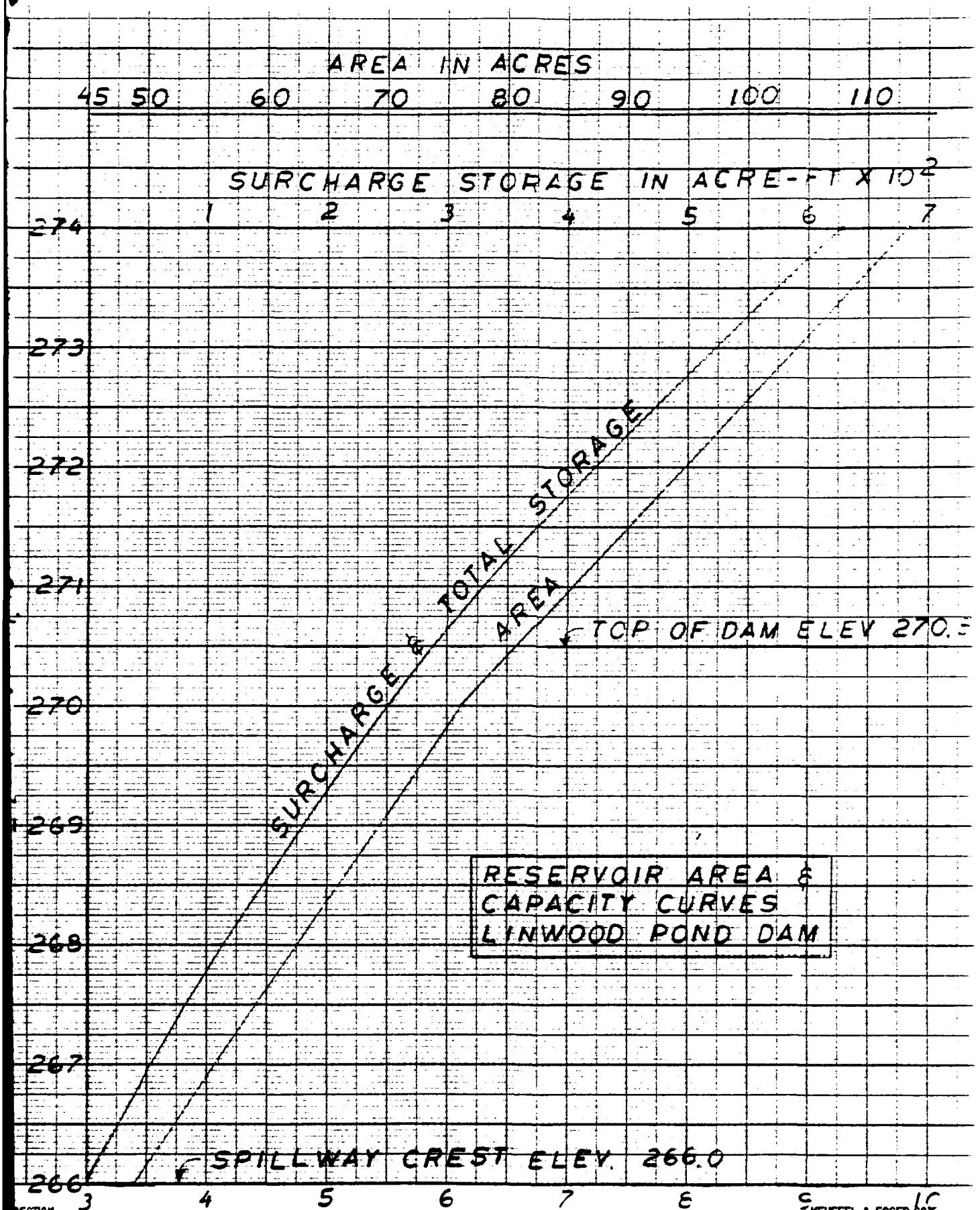
SUBJECT LINWOOD POND DAM - STORAGE CAPACITY

NORMAL STORAGE VOL = $\cdot HA^{1/3}$

$VOL = (270.5 - 253.0)(48.7)(\frac{1}{3}) = 284$ ACRE-FT

SAY NORMAL STORAGE = 300 ACRE-FT

ELEV.	AREA ACRES	AVE AREA	H	Δ STORAGE	TOTAL STORAGE	SURCHARGE STORAGE
266	48.7				300	
268	62.4	55.6	2	111.2	411	111
270	76.2	69.3		138.6	550	250
272	94.8	85.5		171.0	721	421
274	113.3	104.0		208.0	929	629
276	131.9	122.6		245.2	1174	874
278	150.4	141.2		282.4	1456	1156
280	169	159.7	▼	319.4	1776	1476


AREA IN ACRES
45 50 60 70 80 90 100 110
SURCHARGE STORAGE IN ACRE-FT X 10²
1 2 3 4 5 6 7
274
273
272
271
270
269
268
267
266
SURCHARGE & TOTAL STORAGE
AREA
TOP OF DAM ELEV 270.5
SPILLWAY CREST ELEV. 266.0
RESERVOIR AREA & CAPACITY CURVES LINWOOD POND DAM
3 4 5 6 7 8 9 10
TOTAL STORAGE IN ACRE FT X 10²
KEUFFEL & ESSER CO. MADE IN U.S.A.

D-5

BY _____ DATE _____

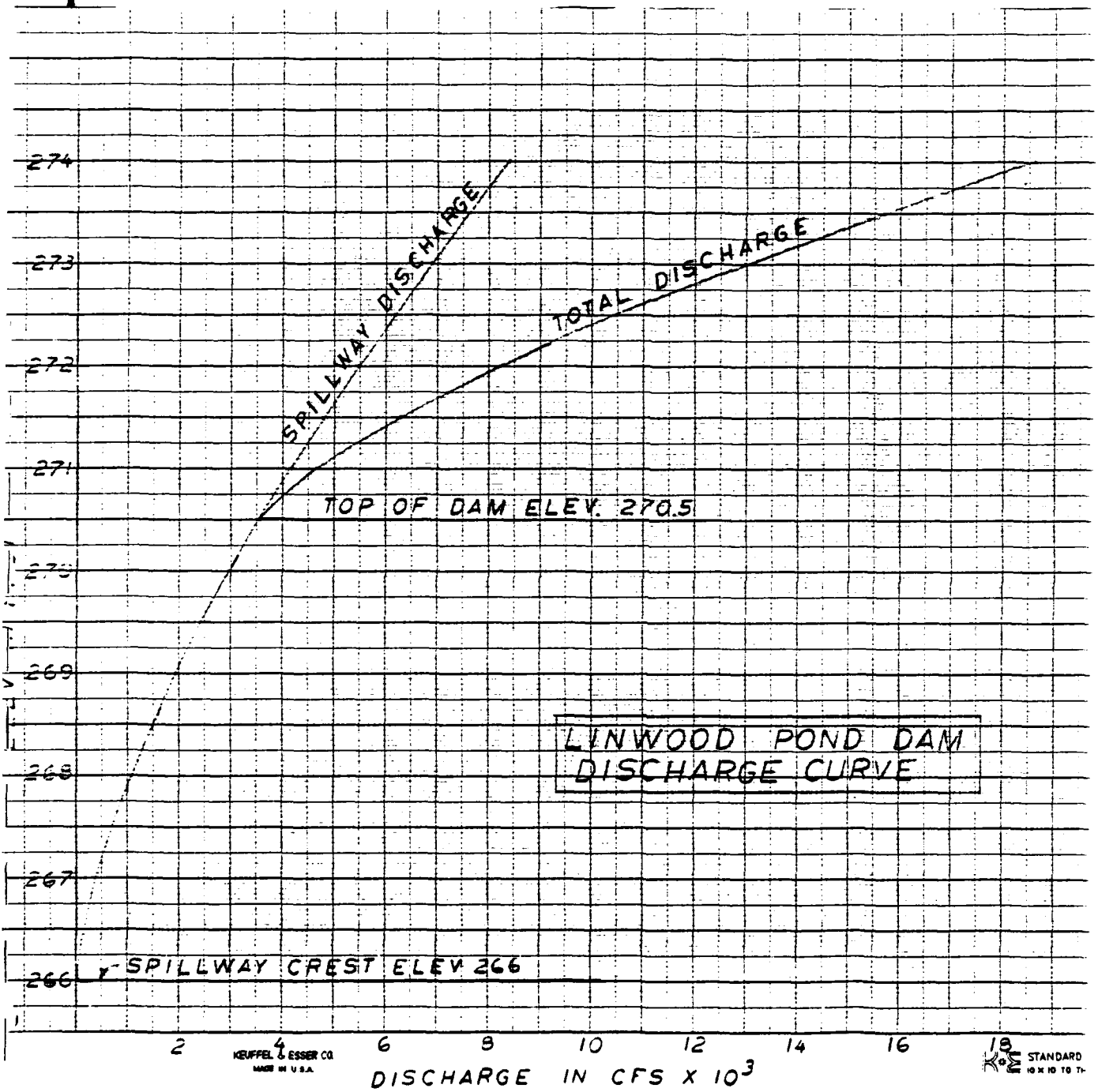
CHKD. BY _____ DATE _____

SUBJECT _____

LOUIS BERGER & ASSOCIATES INC.

SHEET NO. _____ OF _____

PROJECT _____



LINWOOD POND DAM
DISCHARGE CURVE

D-7

BY RFB DATE 4-3-80 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 1 OF

CHKD. BY DATE INSPECTION OF DAMS PROJECT N-198

SUBJECT LINWOOD POND #11 DEVELOPMENT OF PMF

DRAINAGE AREA = 50.4 SQ. MI
SIZE CLASSIFICATION = SMALL
HAZARD CLASSIFICATION = HIGH
INSPECTION FLOOD = ½ PMF TO PMF

CALCULATE PMF USING "PRELIMINARY GUIDANCE FOR ESTIMATING MAXIMUM PROBABLE DISCHARGES IN PHASE I DAM SAFETY INVESTIGATIONS, MARCH 1978.

USE MAXIMUM PROBABLE FLOOD PEAK FLOW RATE CURVES, PICK POINT ONE HALFWAY BETWEEN ROLLING TERRAIN CURVE AND FLAT & COASTAL CURVE.

FOR 50.4 SQ. MI ∴ MPF = 700 CFS/SQ. MI

PMF = 50.4 (700) = 35,300 CFS

½ PMF = 50.4 (350) = 17,600 CFS

¼ PMF = 50.4 (175) = 8,800 CFS ≈ 100 YR FREQ

BY RFB DATE 5-21-80 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 1 OF 4

CHKD. BY DATE INSPECTION OF DAMS PROJECT W-125

SUBJECT LINWOOD POND DAM, FAILURE ANALYSIS

ASSUME DAM FAILS WHEN WATER LEVEL IS AT TOP OF DAM, ELEVATION 270.5 FT

STORAGE @ ELEV. 270.5, S = 590 ACRE-FT

ASSUME LENGTH TO FAIL IS 40% OF EMBANK
AREA = (290 + 282) × 40% = 229 FT = W

HEIGHT = 270.5 - 253 = 17.5 FT = Y_o

$$Q_{p1} = 8/27\, W \sqrt{g}\, Y_o^{3/2}$$

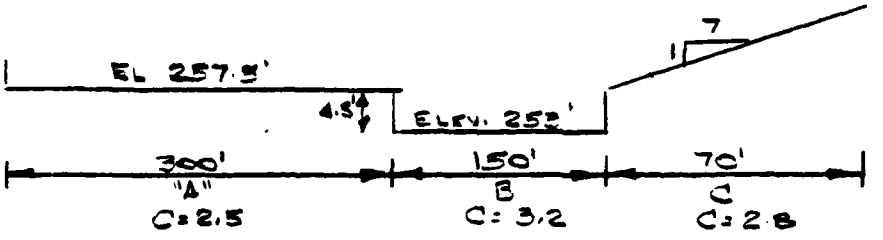
$$Q_{p1} = 1.68\, W\, Y_o^{3/2}$$

$$Q_{p1} = 1.68\,(229)(17.5)^{3/2} = 28,164$$

$Q_{spillway}$ = 3,544 CFS

TOTAL Q_{p1} = 28,164 + 3,544 = 31,700 CFS

ROUGH DIMENSIONS WHITIN POND DAM



ELEV.	A		B		C			S
	H	Q	H	Q	H	L	Q	Q
253	0	0	0	0	0	0	0	0
255	0	0	2	1358	0	0	0	1360
256.5	0	0	3.5	3143	0	0	0	3140
257.5	0	0	4.5	4582	0	0	0	4580
259	1.5	1378	6	7055	0.75	18	33	8470
261	3.5	4911	8	10860	1.75	24	160	15930
263	5.5	9674	10	15178	2.75	30	485	25340
264	6.5	12428	11	17511	3.25	46	755	30690

BY RFB DATE 5-21-80 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 2 OF 4

CHKD. BY DATE INSPECTION OF DAMS PROJECT W-195

SUBJECT LINWOOD POND DAM, FAILURE ANALYSIS

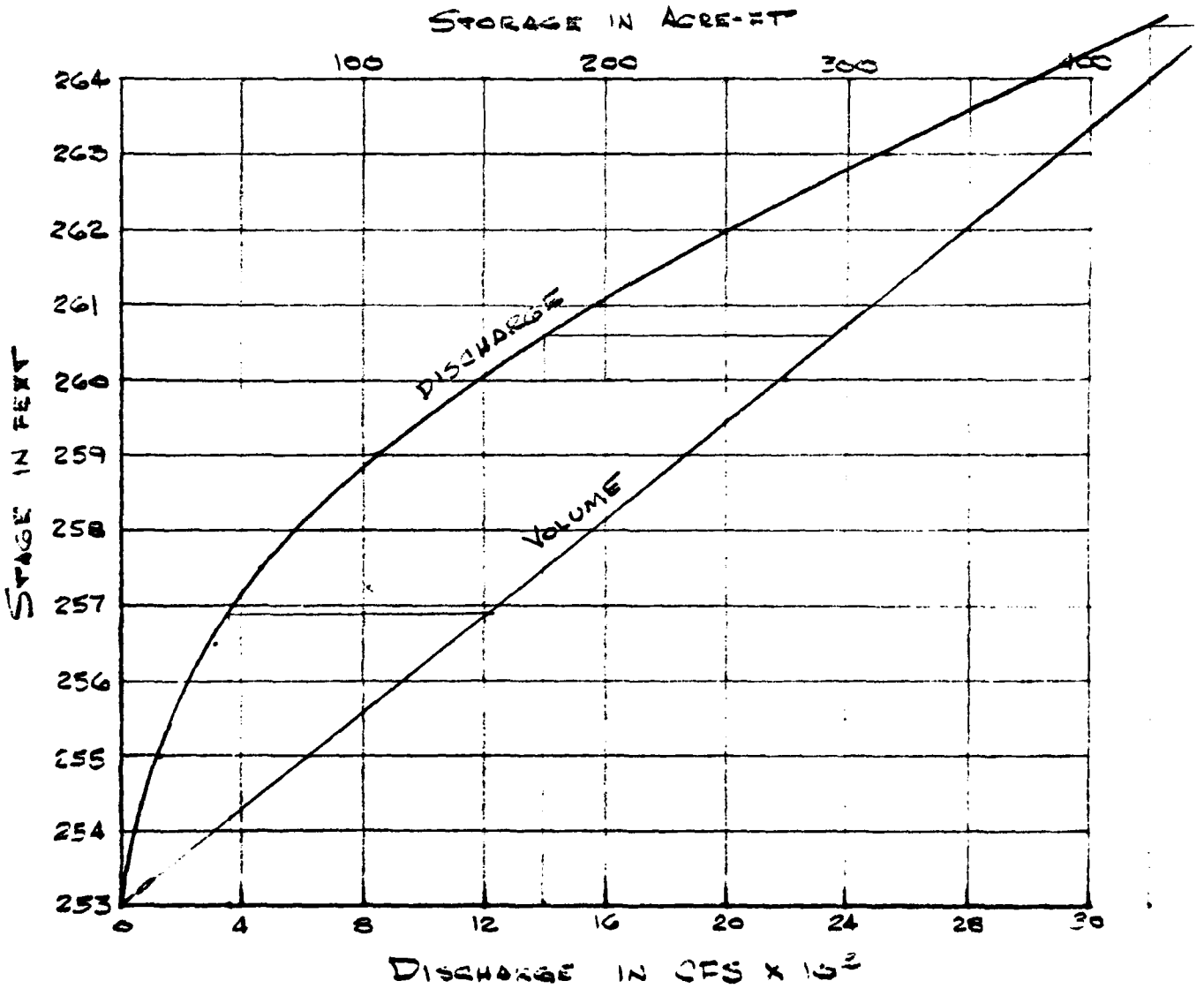
FIND SURCHARGE VOLUME OF WATER POND

AREA @ ELEV. 253 = 29.4 ACRES

AREA @ ELEV. 260 = 48.7 ACRES

SURCHARGE VOLUME = $\left(\frac{48.7+29.4}{2}\right)7$ = 274 ACRE-FT ≅ 260

" " = 0 " " @ 253



FOR Q = 31,700, STAGE = 264.7 FT, VOLUME = 450 A-F

FOR Q = 3,540, STAGE = 256.9, VOLUME = 150 AF

$\Delta V = V_1 = 300$ AF

$$Q_{p2(TRIAL)} = 31,700\left(1 - \frac{V_1}{3}\right) = 31,700\left(1 - \frac{300}{540}\right)$$

$Q_{p2(TRIAL)} = 13,970$ CFS

FOR Q = 13,970, STAGE = 260.6, VOLUME = 290 AF

$-\ 150$

$\Delta V = V_2 = 140$ AF

$$V_{AVE} = \frac{300+140}{2} = 220 \text{ AF}$$

$$Q_{p2} = 31,700\left(1 - \frac{220}{540}\right) = 19,880 \text{ CFS}$$

STA 42+00

FOR Q = 19,880, STAGE = 9 FT, $\Delta H = 5.3$ FT

STA 42+00 TO STA 112+00

VALLEY STORAGE IS ABOUT THE SAME AS FOR REACH #1, ASSUME DISCHARGE REDUCES AT SAME RATE AS IN REACH NO. 1

REACH #1 : $\frac{19,880}{31,700}$ / 4200 FT = 0.63 PER 4200 FT

STA 84+00 $Q_{p2} = 0.63(19,880) = 12,524$ CFS

STA 112+00 $Q_{p2} = 12,524 - (.37)\left(\frac{2800}{4200}\right)(12,524)$

$Q_{p2} = 12,524 - 3089$

$Q_{p2} = 9,400$ CFS

$\Delta H = 260 - 257 = 3$ FT

BY RFB DATE 5-22-90 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 4 OF 4

CHKD. BY DATE INSPECTION OF DAMS PROJECT W-135

SUBJECT LINWOOD POND DAM, FAILURE ANALYSIS

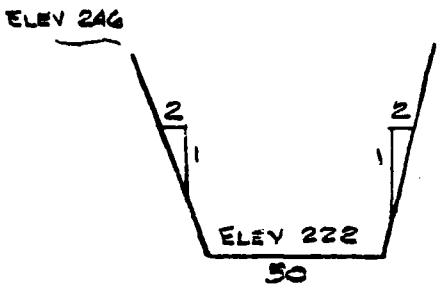
STA 114+00 $Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$

$Q = 2.09\ A R^{2/3}$

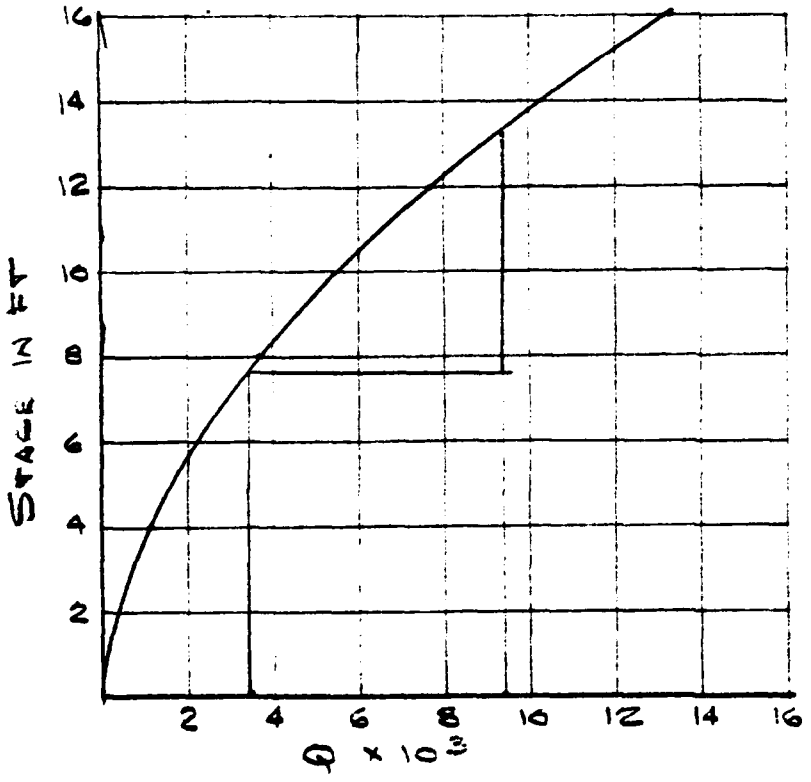
$S = \frac{2}{350} = .006$

$S^{1/2} = .062$

$n = .045$



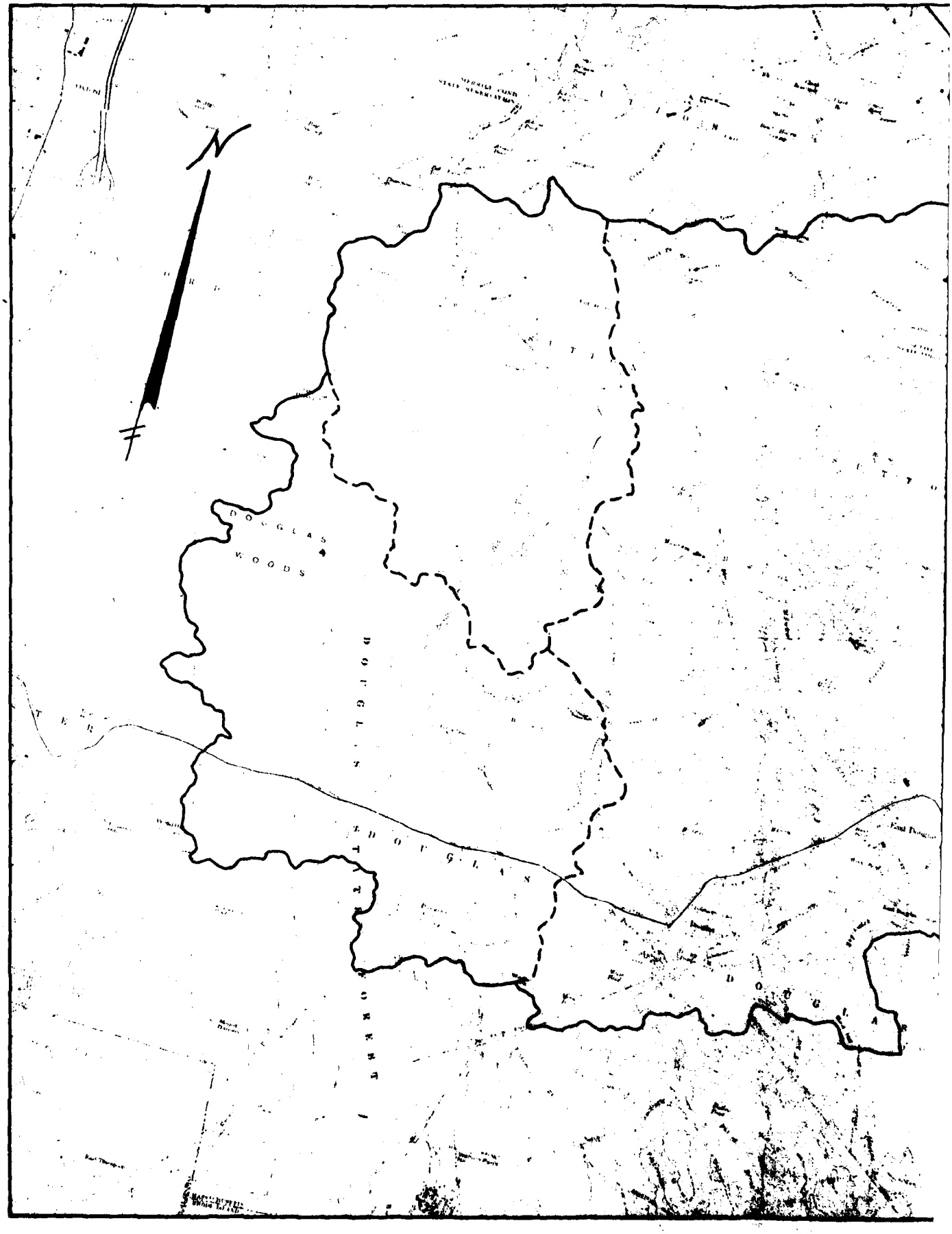
STAGE	AREA	P	R	$R^{2/3}$	Q
4	232	67.9	3.42	2.27	1095
8	528	85.8	6.15	3.36	3690
12	888	103.7	8.56	4.19	7740
16	1312	121.6	10.79	4.89	13344

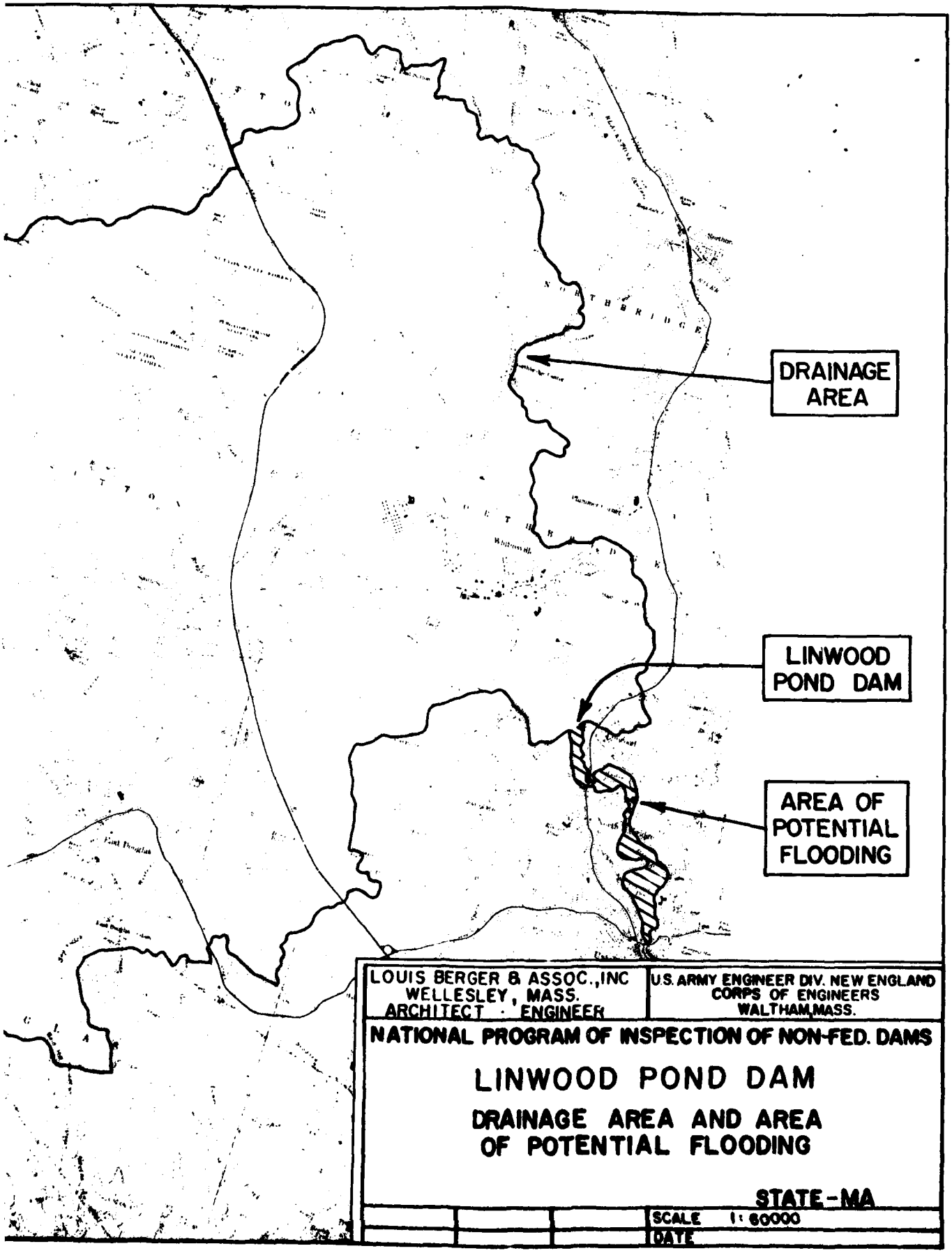


NO SIGNIFICANT STORAGE THIS REACH

$\Delta H = 13.3 - 7.6$

$\Delta H \cong 6$


N
DOUGLAS
WOODS



LOUIS BERGER & ASSOC., INC WELLESLEY, MASS. ARCHITECT · ENGINEER	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

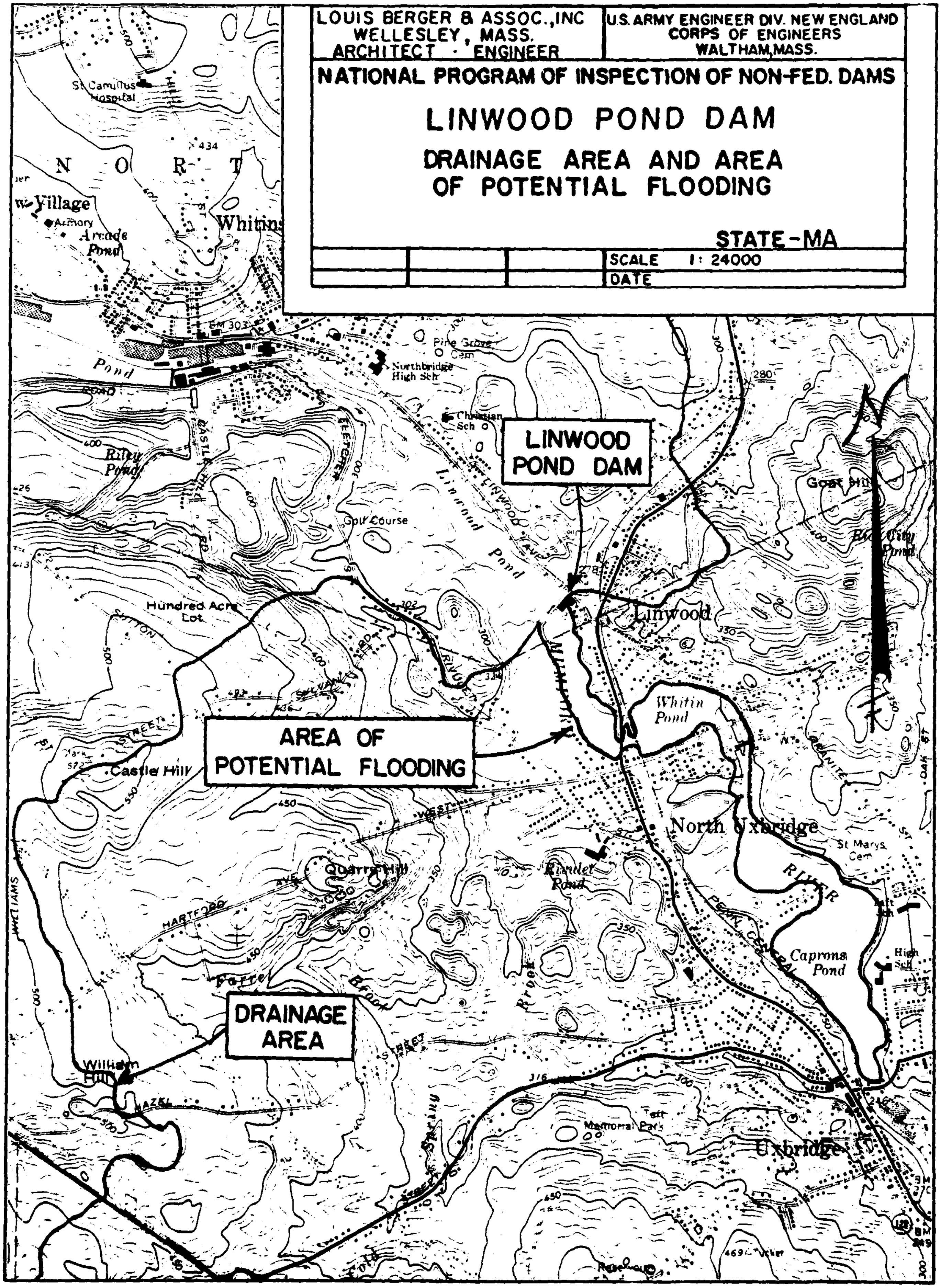
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LINWOOD POND DAM

DRAINAGE AREA AND AREA OF POTENTIAL FLOODING

STATE - MA

SCALE	1: 60000
DATE	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LINWOOD POND DAM
DRAINAGE AREA AND AREA
OF POTENTIAL FLOODING
STATE-MA
SCALE 1: 24000
DATE
LINWOOD
POND DAM
AREA OF
POTENTIAL FLOODING
DRAINAGE
AREA
Linwood
Whitin Pond
North Uxbridge
Uxbridge
Goat Hill
Castle Hill
Quarry Hill
Hundred Acre Lot
Riley Pond
Arcade Pond
Rivulet Pond
Caprons Pond
Linwood Pond
Pine Grove Cem
Northbridge High Sch
Christian Sch
Golf Course
St Camillus Hospital
St Marys Cem
High Sch
Memorial Park
William Hill
RIVER
SCALE

Appendix E

Information as Contained in the National Inventory of Dams

INVENTORY OF DAMS IN THE UNITED STATES

(1) STATE	(2) IDENTITY NUMBER	(3) DIVISION	(4) STATE	(5) COUNTY	(6) CONGR DIST.	(7) STATE	(8) COUNTY	(9) CONGR DIST.	(9) NAME	(10) LATITUDE (NORTH)	(11) LONGITUDE (WEST)	(12) REPORT DATE DAY | MO | YR
MA	696	NED	MA	027	03				LINWOOD POND DAM	4205.8	7138.4	17APR80

(13) POPULAR NAME	(14) NAME OF IMPOUNDMENT
	LINWOOD POND

(15) REGION	(16) BASIN	(17) RIVER OR STREAM	(18) NEAREST DOWNSTREAM CITY-TOWN-VILLAGE	(19) DIST FROM DAM (MI.)	(20) POPULATION
01	09	MUMFORD RIVER	LINWOOD	0	2000

(21) TYPE OF DAM	(22) YEAR COMPLETED	(23) PURPOSES	(24) STRUCTURAL HEIGHT (FT.)	(25) HYDRAULIC HEIGHT (FT.)	(26) IMPOUNDING CAPACITIES MAXIMUM (ACRE-FT.)	(27) NORMAL (ACRE-FT.)	DIST	DAM	FED R	PRV/FED	SCS A	VER/DATE
PGRE	1865	O	18	18	590	300	NED	N	N	N	N	

(28) REMARKS
23=IRRIGATION FOR GOLF COURSE

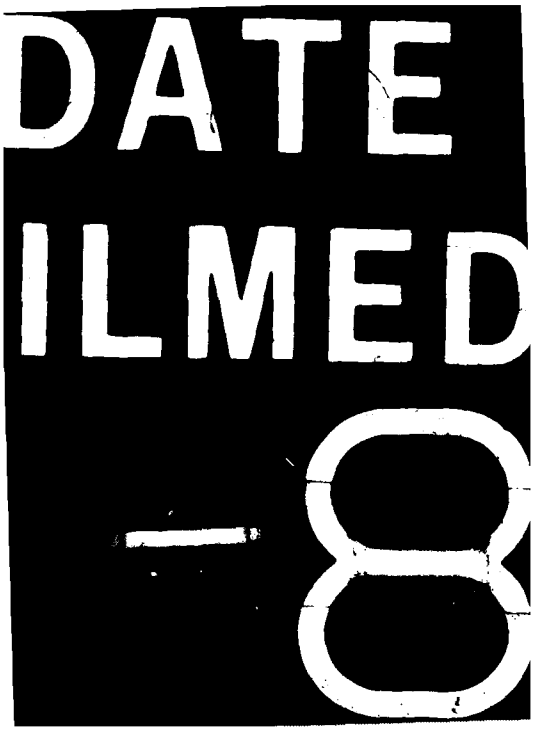
(29) D/S HAS	(30) SPILLWAY CREST LENGTH	(31) SPILLWAY TYPE	(32) SPILLWAY WIDTH (FT.)	(33) MAXIMUM DISCHARGE (FT.)	(34) VOLUME OF DAM (CY)	(35) POWER CAPACITY INSTALLED (MW)	(36) POWER CAPACITY PROPOSED (MW)	(37) NAVIGATION LOCKS NO.	(38) LENGTH (FT.)	(39) WIDTH (FT.)	(40) LENGTH (FT.)	(41) WIDTH (FT.)	(42) LENGTH (FT.)	(43) WIDTH (FT.)	(44) LENGTH (FT.)	(45) WIDTH (FT.)
1	689	U	116	3550	12200											

(46) OWNER	(47) ENGINEERING BY	(48) CONSTRUCTION BY
LUSIGNON CORPORATION		G BLANCHARD

(49) REGULATORY AGENCY			
DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NONE	NONE	NONE	NONE

(50) INSPECTION BY	(51) INSPECTION DATE DAY | MO | YR	(52) AUTHORITY FOR INSPECTION
LOUIS BERGER & ASSOC INC	17APR80	PL 92-367

(53) REMARKS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-8