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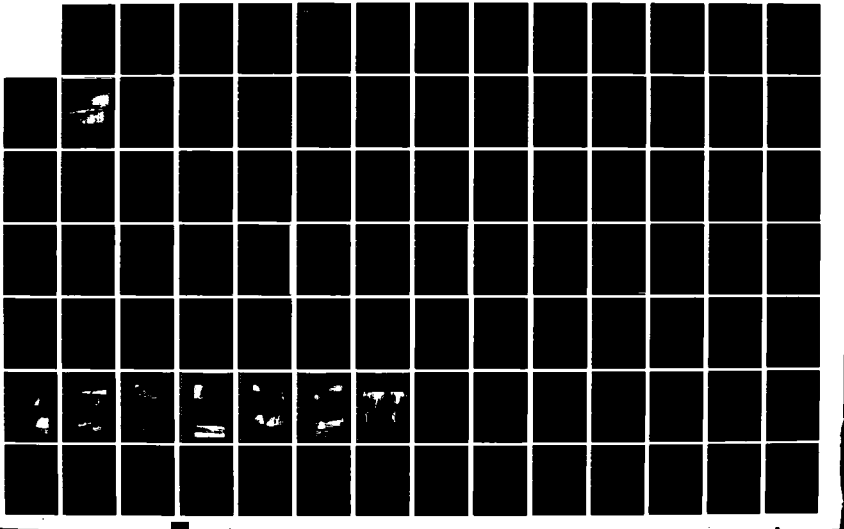

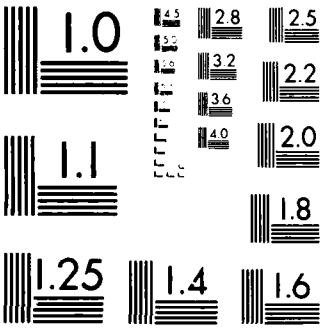

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BLACKSTONE RIVER BASIN
LEICESTER, MASSACHUSETTS

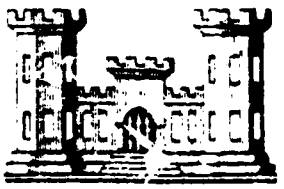
LYNDE BROOK RESERVOIR DAM

MA 00990

EAST DIKE

MA 01290

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



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

MAY 1980

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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
Leicester, Massachusetts
Lynde Brook

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

The dam is an earth embankment about 58 ft. high and 500 ft. long, and has a core masonry wall. The dam is judged to be in generally good condition, however the overall rating must be fair due to spillway inadequacy.There is minor seepage at two locations along the downstream toe.

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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 14 1980

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

Dear Governor King:

Inclosed is a copy of the Lynde Brook Reservoir Dam (MA-00990-Dam) and (MA-01290-East Dike) 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 Lynde Brook Reservoir Dam and East Dike would likely be exceeded by floods greater than 13 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.

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, City of Worcester, 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

LYNDE BROOK RESERVOIR DAM

MA 00990

EAST DIKE

MA 01290

BLACKSTONE RIVER BASIN
LEICESTER, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT

Identification No.:	MA 00990
Name of Dam:	Lynde Brook Reservoir Dam
Town:	Leicester
County and State:	Worcester County, Massachusetts
Stream:	Lynde Brook
Date of Inspection:	16 April 1980

BRIEF ASSESSMENT

Lynde Brook Reservoir Dam, constructed in 1876, is an earth embankment about 58 ft. high, 500 ft. long and has a masonry core wall. The left abutment of the dam appears to be a manmade promontory. This promontory also serves as the right abutment of a 1,050 ft. long, 14.5 ft. high dike located east of the dam. The dike also has a masonry core wall. The upstream slopes of both embankments are random rock riprap. The crest and downstream slopes are grass covered. There are two outlet facilities for the reservoir; a submerged intake tower at the dam and a gate house at the dike. The reservoir can be drawn down by means of a 24 in. dia. blowoff pipe at the main dam.

The reservoir is about 4,700 ft. long and the surface area of the pond at spillway crest is about 124 acres. The drainage area above the dam is about 2.80 sq. mi. (1,795 acres), the maximum storage to top of dam is about 2,737 acre-ft., and the height of the dam is about 58 ft. Based on height and storage, the size classification is intermediate. A breach of the dam would damage 21 homes, seven commercial establishments, three mill complexes, a state route, several other roadways and potentially cause the loss of more than a few lives. Therefore, the dam has been classified as having a high hazard potential. Based upon the guidelines, the recommended test flood is a full PMF (4,970 cfs).

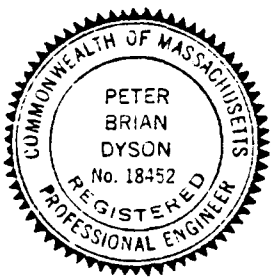
The routed test flood outflow (4,350 cfs) would overtop the dam by about 1 ft. The spillway can pass about 560 cfs or about 13 percent of the routed test flood outflow without overtopping the dam.

The dam is judged to be in generally good condition structurally, however the overall rating must be fair due to spillway inadequacy. There is minor seepage at two locations along the downstream toe. The dike is also judged to be in good condition. There was no evidence of seepage along the downstream slope of the dike. Both the dam and dike, as well as the outlet facilities, are kept in good working condition.

Within one year after receipt of this Phase I Inspection Report, the owner, the City of Worcester, should retain the services of a registered professional engineer and implement the results of his evaluation of the following: (1) a detailed hydrologic-hydraulic investigation to assess further the potential for overtopping and the adequacy of the spillway; (2) a yearly evaluation of the seepage at the downsteam toe of the dam; (3) investigate possible relocation of gate controls to upstream side of embankment; and, (4) whether spillway discharge channel modifications are required to forestall possible overtopping of the walls.

The owner should also implement the following operating and maintenance measures: (1) develop a formal surveillance and downstream emergency warning plan including round-the-clock monitoring during periods of heavy precipitation; (2) institute procedures for an annual technical inspection of the dam and its appurtenant structures, including the minor seepage; and, (3) prepare a copy of the dam outlet control plan.

Peter B. Dyson
Project Manager



This Phase I Inspection Report on Lynde Brook Reservoir Dam & East Dike 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, MEMBER
Design Branch
Engineering Division

[illegible], MEMBER
[illegible]

ARAM T. KAMINSKIAN, CHAIRMAN
Geotechnical Engineering Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
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 not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize 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.

TABLE OF CONTENTS

SECTION 3 - EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

3.1 General

Lynde Brook Reservoir Dam consists of two earth embankments impounding a normal storage of 2,000 acre-ft. with provision for an additional 437 acre-ft. of capacity in its surcharge space to the top of the dam. It is basically a high storage - low spillage facility used for water supply purposes. The spillway is capable of discharging about 560 cfs with the surcharge to the top of dam. The general topographic characteristics of the 2.80 sq. mi. (1,795 acre) drainage basin is best described as rolling terrain, which rises from elevation 824.0 at spillway crest to elevation 1,360. The upper reach of the drainage area is moderately populated and the Worcester Municipal Airport occupies the middle of the area. Southwick Pond is also located in the upper reaches of the drainage area. From the adjacent westerly drainage area an aqueduct drains to Lynde Brook Reservoir from Kettle Brook Reservoir No. 1. However, the inflow from Kettle Brook Reservoir No. 1 to the drainage basin is considered negligible for maximum flow computations.

3.2 Design Data

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

3.3 Experience Data

The only records available in regard to past operation of the reservoir are of water levels. These records are kept in the Worcester City Hall. It was reported by the operator of the dam that the dam has never been overtopped.

3.4 Test Flood Analysis

Hydrologic and hydraulic characteristics of Lynde Brook Reservoir 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. 2,000 ft. per in. quadrangle sheets. Reservoir area and capacity curves and tables, for use in flood routing, are shown on Sheets D-2 and D-3, Appendix D.

As indicated in Section 1.2, paragraphs c and d, Lynde Brook Reservoir Dam is classified as intermediate in size and has a high hazard potential. The recommended test flood for the hydraulic evaluation of such a dam is a full PMF.

Precipitation data were obtained from Hydrometerological Report No. 33, which for this area of Massachusetts is 23.0 in. of 6 hour maximum rainfall over a 10 square mile area. This value was then reduced by 20 percent to allow for basin size, shape and fit factors; an additional 0.4 in.was deducted for infiltration losses. The six hour rainfall was distributed into one hour incremental periods as suggested in Corps of Engineer Publication EC 1110-2-1411.

A triangular incremental unitgraph was assumed for the inflow hydrograph using a computed lag time of 4.38 hours to derive a time-to-peak for the triangular unitgraph of 4.9 hours (see computations on Sheets D-6 and D-7, Appendix D). The test flood hydrograph is shown on Sheet D-8, Appendix D, indicating a peak inflow of about 4,970 cfs or about a PSM value of 1,775.

SECTION - - OPERATIONAL AND MAINTENANCE PROCEDURES

-.1 Operation Procedures

a. General. The dam is owned and operated by the City of Worcester Water Department. It is operated in conjunction with several other reservoirs to supply municipal water. A 24 in. dia. aqueduct connects it to Kettle Brook Reservoir No. 1 upstream. In the winter Lynde Brook Reservoir is generally drawn down slightly below the spillway crest elevation in order to provide storage for the excess spring runoff from other reservoirs.

b. Description of any Warning System in Effect. No warning system is in effect at Lynde Brook Reservoir Dam. The dam is visited daily.

-.2 Maintenance Procedures

a. General. There is no documented regular periodic maintenance program in effect at Lynde Brook Reservoir Dam. There are, however, several items which require and evidently receive periodic maintenance, such as: the upkeep of sod on the crest and downstream slope of the dam and dike; the removal of debris from the spillway crest; the repair of the spillway training walls; the surveillance of the embankment regarding seeps; and, the maintenance of the outlet structures and gates.

b. Operating Facilities. All outlet facilities appear to be well maintained and are reported to be in operating condition.

-.3 Evaluation

Overall maintenance of the dam is generally good. Specific maintenance items are evaluated as follows: the sod on the crest and downstream slope of both the dam and dike is in excellent condition; the crest of the spillway was free of debris; the spillway training walls are in good condition; there are two seeps along the downstream toe of the dam; and, all outlet facilities are reported to be in operating condition. The owner should establish a formal warning system for the dam in the event of an emergency.

The top of the submerged intake tower is about 20 ft. below the top of dam. A steel grate serves as the top of the masonry structure. The inlets to two outlet pipes are at the bottom of the intake tower. A third outlet pipe originally also had its inlet at the bottom of the intake tower; however, this pipe has been extended through the intake tower and up into the reservoir to serve as a blowoff or mud pipe. All three outlet pipes are 24 in. dia. and have their inverts about 42 ft. below the top of dam.

These three outlet pipes are carried under the dam via a stone box culvert and emerge into a gate house located at the downstream toe of the dam. In the brick gate house there are manual gate valves and stems for controlling outflows. The right and center outlet pipes provide water for the municipal water supply system and cannot be used for reservoir drawdown. A brick chlorination house is located about 75 ft. downstream of the gate house. From here chlorine is added to the municipal water system. The left outlet pipe serves as the blowoff or mud pipe and outlets through a rubble masonry headwall about 200 ft. downstream of the gate house. All three outlet pipes are reported to be in good working condition (see Appendix C, Photo Nos. 11, 13 & 14).

A gate house is located about 180 ft. right of the left abutment of the east dike and is accessed by an approximately 35 ft. long catwalk from the crest of the dike. There is only one outlet pipe from the granite ashlar masonry gate house on the dike. This 30 in. dia. pipe is controlled by a slide gate in the gate house and flows into the municipal water supply system. The slide gate is reported to be in working condition (see Appendix C, Photo No. 12). The invert of the pipe is about 22 ft. below top of dike. In general the outlet facilities appear to be well maintained and in good working order.

d. Reservoir Area. The reservoir behind the dam and dike is an impoundment of Lynde Brook. The shoreline upstream of the dam and dike is in excellent condition with no evidence of slides, movements or distress. A 24 in. dia. aqueduct carries excess runoff from the Kettle Brook Reservoirs to Lynde Brook Reservoir.

e. Downstream Channel. At the downstream end of the spillway chute and where the blowoff pipe headwall is located, there is heavy rock riprap. From this point Lynde Brook flows through a steep narrow valley section for about 2,800 ft. before reaching State Route 9. At Route 9 the valley widens and flattens, and there are numerous residential and commercial buildings in this area. About 600 ft. below Route 9, Lynde Brook flows into Smiths Pond and Dam. Beyond Smiths Pond Lynde Brook is known as Kettle Brook and it follows a relatively narrow ravine for a distance of about 2,400 ft. Beyond this point the channel begins to widen and about 3 miles downstream of the dam it flows into Stoneville Pond (see Appendix D, Drawing D-20).

3.2 Evaluation

In general, the visual inspection adequately revealed key characteristics of the dam as they may relate to its stability and integrity, permitting an assessment to be made of those features affecting the safety of the structure. Minor seepage was noted from two areas along the downstream toe of the dam. No seepage was evident along the downstream slope of the dike. The crest and downstream slope of the dam and dike are well maintained. The outlet facilities all appeared to be in good working condition. Downstream control of the outlet gates is not advisable due to a continuous head in the conduit beneath the embankment. The spillway training walls are in good repair. The downstream spillway discharge channel training walls are low and may be overtopped during periods of high flow. For thes reasons the Dam and Dike were judged to be in fair condition.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

a. General. The visual inspection of Lynde Brook Reservoir Dam took place on 16 April 1980. On that date the water level was just below the spillway crest and wave action was causing it to slightly lap over the crest. There was no evidence of major problems, but there is minor seepage at two locations downstream of the dam. The dam and dike are judged to be in good physical condition.

b. Dam. Lynde Brook Reservoir, an impoundment of Lynde Brook, consists of a dam, dike, spillway and outlet facilities. It provides storage for excess run-off from other reservoirs and is operated by its owner, the Worcester Water Dept., in conjunction with these other reservoirs as a municipal water supply facility.

The dam is an earth embankment with a masonry core wall. It is about 500 ft. long, 38 ft. high and has a crest width of about 50 ft. The crest and 2½ horizontal to 1 vertical downstream slope are grass covered and well maintained. The upstream slope is of random rock riprap (see Appendix C, Photo Nos. 1 & 2). The left abutment is a promontory which appears to be man-made, between the dam and the dike located east of the dam (see Appendix B, Sketch Plan pg. B-1). The reservoir rim along the left abutment is random rock riprap and the crest of the abutment is sodded. A paved access road to reservoir outlet facilities is located across the crest of the abutment about 300 ft. from the reservoir rim. At the downstream toe of the junction of the dam and left abutment there is a minor seep estimated to be about 0.1 gpm. This seepage apparently passes under the access road, as there is a soft wet area to the left of the roadway (see Appendix C, Photo No. 7). There is another seepage area at the downstream toe of the dam about mid-dam and its flow is estimated to be less than 0.1 gpm. Both seeps are discharging clear colorless water (see Appendix C, Photo Nos. 5 & 6). In general the dam embankment is in good condition.

Dike. The dike is also an earth embankment with a masonry core wall. It is about 1,050 ft. long, 14.5 ft. high and has a crest width of about 42 ft. The crest and 1 2/3 horizontal to 1 vertical downstream slope are grass covered and well maintained. The upstream slope is of random rock riprap. At the time of the inspection there was no evidence of seepage along the dike. In general the dike is in excellent condition (see Appendix C, Photo Nos. 3 & 4).

c. Appurtenant Structures. The spillway for the facility is located at the right abutment of the dam. The spillway has a net crest length of 28.8 ft. between grouted ashlar masonry training walls. An 8 in. high steel angle iron serves as the fixed crest. The top of dam is 3.5 ft. above the spillway crest. The upstream approach apron is paved with concrete grouted riprap. The 7 horizontal to 1 vertical downstream spillway channel converges from the 28.8 ft. wide spillway crest to about 16 ft. just downstream of the crest. It has 2.5 ft. high mortared rubble masonry training walls and is paved with concrete grouted riprap. At the end of the 345 ft. long spillway chute there is heavy random rock riprap. The spillway is in generally good condition (see Appendix C, Photo Nos. 8, 9 & 10).

There are two outlet facilities for Lynde Brook Reservoir. A submerged intake tower is located about 200 ft. left of the right abutment of the dam and about 50 ft. upstream of the crest of the dam.

SECTION 2 - ENGINEERING DATA

2.1 Design Data

The only data recovered concerning the design of the dam or appurtenances are the three plans found in Appendix B and a plan of the dam's outlet controls. A copy of this plan is not included in this report, as the only known copy is securely fastened to a wall inside the chlorinating house at the toe of the dam.

2.2 Construction Data

No records or correspondence regarding construction of the dam have been recovered.

2.3 Operation Data

No records or correspondence regarding past operation of the dam have been recovered. The only known operating records appear to be those of the chlorinating process and the recording of water levels. These records are maintained on a daily basis and are stored in the Worcester City Hall.

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

(3) Height - 57.7 ft.		14.3 ft.
(4) Top Width - 30 ft.		42 ft.
(5) Side Slopes - Downstream: 2½ H to 1 V. Upstream: Unknown		Downstream: 1 2/3 H. to 1 V. Upstream: Unknown
(6) Zoning - Unknown		Unknown
(7) Impervious Core - Masonry Core Wall		Masonry Core Wall
(8) Cutoff - Unknown		Unknown
(9) Grout curtain - Unknown		Unknown

h. Diversion and Regulating Tunnel - Not Applicable

i. Spillway

(1) Type - Ashlar and rubble masonry with mortared joints, wasteway

(2) Length of weir - 28.8 ft.

(3) Crest elevation (with angle iron sill) - 824.0

(4) Gates - None

(5) U/S Channel - Reservoir

(6) D/S Channel - Converging, 16 ft. wide rubble masonry, with mortared joints wasteway

j. Regulating Outlets

(1) Invert - Elev. 784.3

(2) Size - 24 in. circular, leading to 48 in. square, leading to 40 in. circular

(3) Description - 24 in. cast iron pipe, leading to 48 in. sq. stone box culvert, leading to 40 in. cast iron pipe

(4) Control Mechanism - Hand operated 24 in. inline gate valve.

(5) There are two 24 in. dia. pipes from the dam gate house and a 30 in. dia. pipe from the dike gate house. All of these pipes feed into the closed water supply system for the City and therefore could not be used as a means of low level withdrawal.

(4) Recreation pool - Not Applicable

(5) Full flood control pool - Not Applicable

(6) Spillway crest - 824.0

(7) Design surcharge (Original Design) - Unknown

(8) Top of dam - 827.35
Top of dike - 827.35

(9) Test flood surcharge - 828.28

d. Reservoir (Length in Feet)

(1) Normal pool - 4,700

(2) Flood control pool - Not Applicable

(3) Spillway crest pool - 4,700

(4) Top of dam - 5,000

(5) Test flood pool - 5,020

e. Storage (acre-feet)

(1) Normal pool - 2,300

(2) Flood control pool - Not Applicable

(3) Spillway crest pool - 2,300

(4) Top of dam - 2,737

(5) Test flood pool - 2,870

f. Reservoir Surface (acres)

(1) Normal pool - 124

(2) Flood control pool - Not Applicable

(3) Spillway crest 124

(4) Top of dam - 138.5

(5) Test flood pool - 142.5

g. Dam	Dike
(1) Type - Earth Fill	Earth Fill
(2) Length - 500 ft.	1,050 ft.

of other reservoirs, is located in a drainage area that is immediately west of the Lynde Brook Pond Dam drainage area and an aqueduct that drains toward Lynde Brook Reservoir connects the two reservoirs.

b. Discharge at Damsite

(1) Outlet Works Conduit. Low level discharge from Lynde Brook Reservoir Dam is provided by a 24 in. dia. outlet pipe which extends from inside the reservoir to a gate house located on an earth bench at the toe of the dam. Flows in the pipe are regulated by a 24 in. gate valve in the gate house. Just downstream of the gate house the 24 in. dia. pipe makes a 90 degree bend to the left and a short distance from this point the 24 in. dia. line discharges into an old 48 in. square stone box conduit, which in turn discharges into a 40 in. dia. cast iron pipe emptying into Lynde Brook at the toe of the dam. At the gate house, the invert of the discharge pipe is about 785(±) ft. NGVD. The waste pipe would be capable of discharging about 61 cfs when the control valve was wide open and the reservoir water surface level was at the top of the dam. There are two other 24 in. dia. pipes and gate valves. These pipes however connect directly into the city water supply system and are not capable of low level withdrawal.

(2) Maximum Known Flood at Damsite. No records are available of flood inflows into Lynde Brook Reservoir, nor of spillway releases and surcharge heads during such inflows.

(3) Ungated Spillway Capacity at Top of Dam. The ungated spillway capacity at top of dam. elevation 827.35, is 560 cfs.

(4) Ungated Spillway Capacity at Test Flood Elevation. The ungated spillway capacity is 830 cfs at test flood elevation 828.3.

(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 test flood elevation 828.3 is the same as (4) above, 830 cfs.

(8) Total Project Discharge at Top of Dam. The total project discharge at top of dam, elevation 827.35 ft., is 620 cfs.

(9) Total Project Discharge at Test Flood Elevation. The total project discharge at test flood is 4,350 cfs at elevation 828.3.

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

(1) Streambed at toe of dam - 768.7±

(2) Bottom of cutoff - Unknown

(3) Maximum tailwater - Unknown

50 and 70 homes, 6 commercial establishments, a school and a church would be severely flooded by the breach discharge. Depths of flooding would range between 1 and 9 ft.

In accordance with the Recommended Guidelines for Safety Inspection of Dams, Lynde Brook Reservoir has therefore been classified as having a high hazard potential, since failure of either the dam or dike would cause serious damage to homes, industries, commercial establishments and highways, with the potential for the loss of more than a few lives.

e. Ownership. Lynde Brook Reservoir Dam is owned by the City of Worcester, Mass.

f. Operator. The operator of the dam is Mr. Ken Starbard, Superintendent, Worcester Water Dept., Worcester, Mass. Telephone (413)829-4811.

g. Purpose of Dam. Lynde Brook Reservoir Dam is operated in conjunction with other water storage facilities for providing municipal water supplies to the City of Worcester.

h. Design and Construction History. Lynde Brook Reservoir and Dam was constructed in 1876. A wood and earth dam said to have been constructed by local Indians previously existed at the site and its submerged remnants are located just upstream of the present dam.

The present dam was designed by Wm. J. McAlpine, Consulting Engineer. Copies of two of the original plans of the dam and dike can be found in Appendix B. There is also a copy of a third plan dated 1897 showing a cross-section through the dike and gate house. There also exists a plan of the outlet facilities of the dam, downstream gate house and chlorination house piping system. This plan is securely fastened to an inside wall of the chlorination house. A sketch copy of it is included in Appendix B.

i. Normal Operating Procedure. There are no written operating procedures for the facility. The reservoir is utilized as a storage facility for excess runoffs from other reservoirs. It is connected to Kettle Brook Reservoir No. 1 immediately upstream via a 24 in. dia. gravity feed conduit (see Location Map, page IV). The only operating devices are the gates and valves associated with the gate house structures. The grass on the crests and downstream slopes is cut periodically and the spillway training walls and chute are repaired as necessary.

1.3 Pertinent Data

a. Drainage Area. The drainage area contributing to Lynde Brook Reservoir encompasses a total of about 2.80 sq. mi. (1,795 acres), of which 124 acres are occupied by the reservoir. The longest circuitous stream course leading to the dam is about 3.71 miles long with an elevation difference of about 391 ft., or at a slope of about 105 ft. per mile. The drainage area has a length of about 3.5 miles and has an average width of about 0.9 miles. The basin consists of both open fields and forested areas with housing developments located in the very upper reaches of the drainage area. Southwick Pond is also situated in the upper reaches of the drainage area and nearly all of the Worcester Municipal Airport is located near the midpoint of the area. Kettle Brook Reservoir No. 1, the last in a series

Lynde Brook Reservoir is connected to a series of other reservoirs via a 24 in. dia. aqueduct (see page IV). The facility is used to store excess runoff from the other reservoirs.

(2) Description of East Dike. A 1,050 ft. long and about 14.5 ft. high dike connects the left abutment of the dam with the northern reservoir rim. This dike has a crest width of about 42 ft. and a downstream slope of about 1 2/3 horizontal to 1 vertical, both of which are sodded. The upstream slope is of random rock riprap. The drawings in Appendix B indicate that the dike has a masonry core wall, however, the elevation is unknown.

(3) Spillway. The spillway for Lynde Brook Reservoir Dam is located at the right abutment of the dam. It has a crest length of 28.8 ft. between the grouted ashlar masonry training walls. An 8 in. high steel angle iron serves as the fixed crest. The top of dam is 3.5 ft. above the spillway crest. Both the upstream approach channel and downstream discharge channel are paved with concrete grouted riprap. The downstream channel converges from about 28.8 ft. to about 16 ft. just downstream of the crest. It has 2.5 ft. high rubble masonry training walls and a slope of 7 horizontal to 1 vertical. At the end of the 345 ft. long channel there is heavy rock riprap.

(4) Outlets. There are two outlet facilities for Lynde Brook Reservoir. A submerged intake tower is located about 200 ft. left of the right abutment of the dam and about 50 ft. upstream of the crest of the dam. The submerged intake tower has three 24 in. dia. cast iron outlet pipes with the inverts located about 42 ft. below the top of dam or about elevation 785(+). These three pipes are carried under the dam in a stone box culvert and enter into a gate house located at the downstream toe of the dam. The level of the top of the inlet tower is unknown. In the gate house there are manual gate valves and stems for controlling outflows. The right and center pipes provide water for the municipal water supply system and cannot be used for reservoir drawdown. A chlorination house located about 75 ft. downstream of the gate house provides chlorine treatment to the discharge from these two outlet pipes. The left outlet pipe is used as a mud pipe or blowoff pipe. It outlets about 200 ft. downstream of the gate house through a rubble masonry headwall. All gates were reported to be in operating condition.

A gate house is located about 180 ft. right of the left abutment of the east dike and is accessed by an approximately 35 ft. long catwalk from the crest of the dike. There is only one outlet from the gate house at the dike. A 30 in. dia. pipe carries flows from the gate house under the dike into the municipal water supply system. Outflows are controlled by a manual slide gate reported to be in operating condition. The invert is estimated to be at about elevation 805 (±).

c. Size Classification. Lynde Brook Reservoir Dam has a hydraulic height of about 58 ft. above downstream river level, and impounds a normal storage of about 2,300 acre-ft. to spillway crest level and a maximum of about 2,737 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 intermediate category on the basis of height and storage and is therefore classified accordingly.

d. Hazard Classification. A breach failure analysis was performed in the event of either a dam or dike failure at Lynde Brook Reservoir. In the initial impact area below the dam it is estimated that about 20 homes, 7 commercial establishments and 3 mill complexes would be severely flooded by the breach discharge. In the initial impact area below the dike it is estimated that between

PHASE I INSPECTION REPORT

LYNDE BROOK RESERVOIR DAM MA 00990

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.

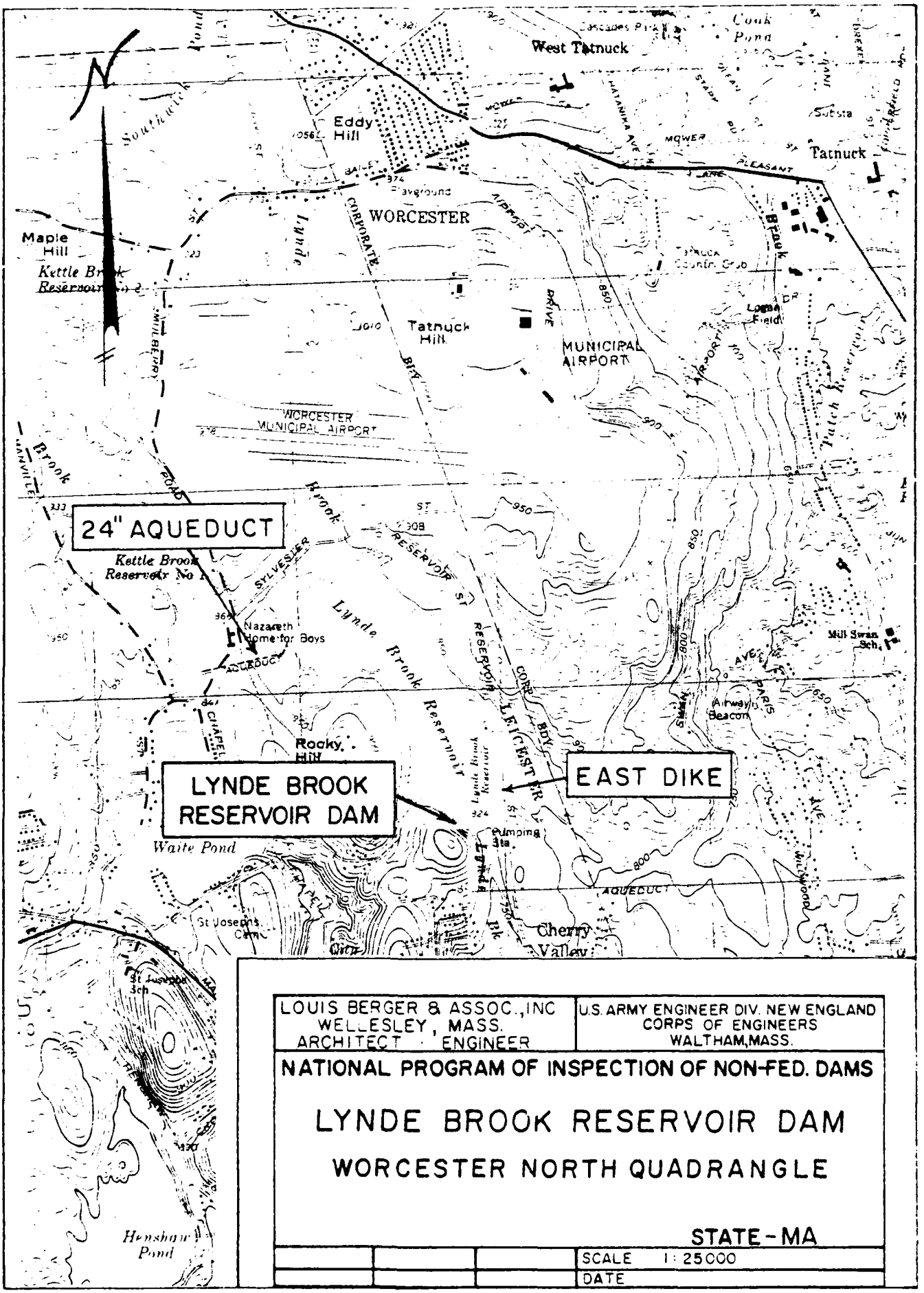
1.2 Description of Project

a. Location. Lynde Brook Reservoir Dam is located in Worcester County in the Town of Leicester in south-central Massachusetts. The reservoir is situated on Lynde Brook approximately 0.7 miles above Smiths Pond. From this pond issues Kettle Brook, which joins the Middle Blackstone River at a point about 6.8 miles below the dam. The dam is shown on U.S.G.S. Quadrangle, Worcester North, Massachusetts, with coordinates approximately at N 42° 15' 07", W 71° 52' 24".

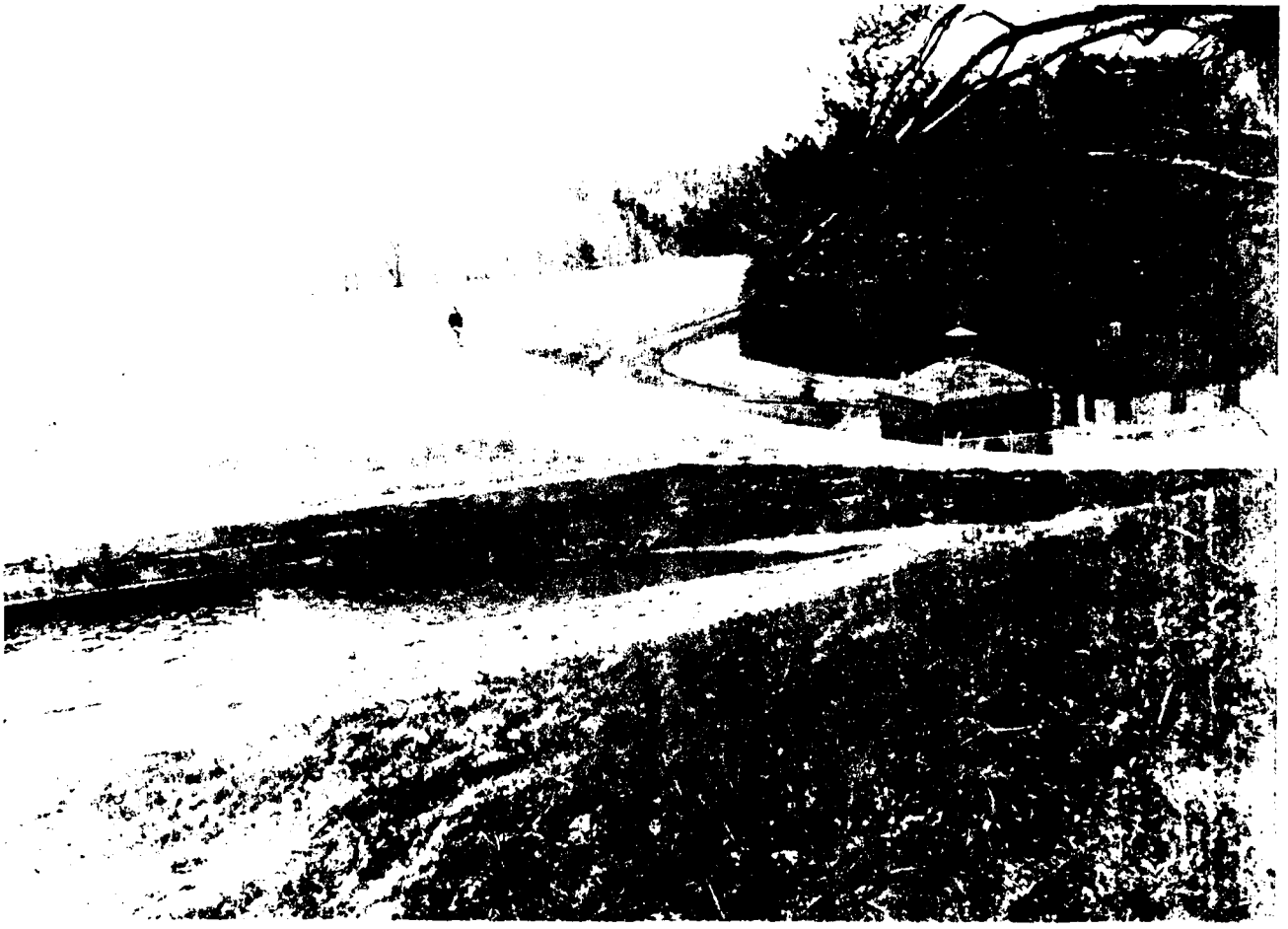
b. Description of Dam and Appurtenances.

(1) Description of Dam. Lynde Brook Reservoir Dam is an earth embankment about 58 ft. high and about 500 ft. long with a masonry core wall. The elevation at the top of the core wall is unknown. The dam was constructed in 1876. The dam has a crest width of about 50 ft. and a downstream slope of about 2½ horizontal to 1 vertical. Both the crest and downstream slope are sodded. The upstream slope is of random rock riprap.

The left abutment of the dam is a promontory, which appears to be man-made, between the dam and a dike located east of the dam. The reservoir rim along the left abutment is random rock riprap and the crest of the abutment is sodded. A paved access road to the reservoir outlet facilities below the main dam is located across the crest of the abutment about 300 ft. from the reservoir rim.


24" AQUEDUCT
LYNDE BROOK RESERVOIR DAM
EAST DIKE
West Tatnuck
Eddy Hill
WORCESTER
Maple Hill
Tatnuck Hill
MUNICIPAL AIRPORT
WORCESTER MUNICIPAL AIRPORT
Tatnuck
Nazareth Home for Boys
Rocky Hill
Waite Pond
Cherry Valley
Henshaw Pond
Lynde Brook Reservoir
Patch Reservoir
Logan Field
Mill Swan Sch.
Airway Beacon
Pumping Sta.
St Joseph's Cem.
St Joseph Sch
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
LYNDE BROOK RESERVOIR DAM
WORCESTER NORTH QUADRANGLE
STATE - MA
SCALE 1: 25000
DATE

LYNDE BROOK RESERVOIR DAM



OVERVIEW OF DAM FROM RIGHT ABUTMENT

APPENDIXES

Discharge tables and curves for the spillway and for over the top of the dam are shown on Sheets D-4 and D-5, Appendix D. The discharge from the 24 in. dia. low level outlet has been neglected.

Flood routings were performed for both the test flood and ½ PMF. Results of these routings are shown on Sheets D-9 thru D-11, Appendix D, and are summarized as follows:

Flood Magnitude	Routed Test Flood Inflow cfs	Maximum Res. El. ft. NGVD	Max. Head Over Main Dam ft.	Routed Test Flood Outflow cfs
PMF (Test Flood)	4,970	828.3	1.0	4,350
½ PMF	2,485	827.9	0.6	2,100

From the above table, it can be seen that the project will not pass the routed test flood outflow without overtopping the dam by 1 ft. The project can handle about 13 percent of the routed test flood outflow without overtopping the dam.

3.3 Dam Failure Analysis

A breach from overtopping or due to structural failure of either the main dam or dike is a possibility. For this analysis a breach of each structure was considered separately as the breach outflows from the structures would initially follow different water courses. The "rule of thumb" method was used as a guide in computing the breach outflows.

Dam Failure. A breach width of 38 percent of the dam length was assumed for this analysis and a failure height from the bench at the toe of the embankment to the top of dam was assumed equal to 31 ft. Using these dimensions an outflow of about 55,000 cfs, which includes about 500 cfs from the spillway, would be realized. (see Sheets D-12 thru D-18, Appendix D).

Discharges from the breach would flow down Lynde Brook, thence to Kettle Brook. There are no structures in close proximity to Lynde Brook until the brook reaches State Route 9 about 2,800 ft. below the dam. However, because of the high breach discharge and small amount of valley storage between the dam and State Route 9, it is considered that severe flooding of commercial establishments and houses will take place in the vicinity of State Route 9. It is estimated that the discharge in this vicinity will be about 47,000 cfs and that the structures will be flooded to depths varying from 1 to 9 ft. About 13 houses and 7 commercial establishements would be flooded in this area. At this location, the culvert passing under State Route 9 is relatively small and it is estimated that State Route 9 would be overtopped by the spillway discharge alone, but no significant flooding of structures would probably take place under the spillway full flow condition. About 600 ft. below State Route 9 Lynde Brook empties into Smiths Pond where it is estimated that there will be flooding of at least five homes and a mill located near the outlet of the pond. The depth of flooding around the structures in this area is estimated to be between 3 and 7 ft. and that no flooding of these structures would occur under the spillway full conditions.

Beyond Smiths Pond the water course is known as Kettle Brook, which follows a relatively narrow ravine for a distance of about 2,400 ft. to another dam which is part of a mill complex. It is estimated that the discharge in the brook at this point will be about 31,000 cfs, and that the brook will rise about 17 ft. because of the breach, severly flooding the adjacent fill. An inspection of the waterway opening under Strafford Street, located about 2.1 miles below Lynde Brook Reservoir Dam, indicated that the capacity of the waterway is adequate to convey the spillway full discharge, but inadequate to handle the breach discharge. The street as well as a mill complex located south of Strafford Street will be significantly flooded. James Street, located about 2,000 ft. further downstream, will also be flooded and three houses near the brook in this area will probably sustain damage. Beyond James Street, the brook empties into Stoneville Pond where the flood wave should be significantly reduced.

Dike Failure. For this failure analysis a breach width of 20 percent of the dike's length at mid-height was used equal to 130 ft. The height of the breach was assumed from the toe of the dike to the top of the embankment a distance of about 14 ft. Using these dimensions an outflow of about 11,300 cfs would be realized. (See Sheets D-21 thru D-25, Appendix D).

Discharges from the breach would flow down an unnamed water course for a distance of about 7,000 ft. until reaching an underground conduit which has twin barrels about 2.5 ft. high and 5 ft. The conduit would not be adequate to handle the breach discharge and it is estimated that about 9,000 cfs would spill across State Route 9, down over a steep embankment and into a large residential area. The outflow would then cross Stafford Avenue and return to Kettle Brook to the same damage reach as described under the dam failure analysis.

About 2,300 ft. below the dike there are about 4 homes in the Cherry Valley section of Leicester that would sustain flooding due to the breach. It is estimated that the depth of flooding in this area would be between 2 and 6 ft. In the area of State Route 9 and the area between State Route 9 and Stafford Avenue, it is estimated that from 50 to 70 homes, 6 commercial establishments, a school and a church would be flooded to depths ranging between 1 and 9 ft.

In summary, in the initial impact areas described above there is considerable urban development and more than a small number of habitable structures which would be flooded by a breach of either the dam or dike at Lynde Brook Reservoir. It is estimated that economic losses due to a breach would be excessive. There is also the potential for the loss of more than a few lives. Sheet D-26, Appendix D shows the area of potential flooding.

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 is now stable and is in good condition. The only deficiency that should be monitored is the minor seepage in two locations at the downstream toe of the dam.

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 post-construction changes made to the dam, dike or spillway that are of significance to the stability of the facility.

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 AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. On the basis of the Phase I visual examination, Lynde Brook Reservoir Dam and Dike appear to be in good condition. Structurally, however the overall rating must be fair due to spillway inadequacy. The deficiencies revealed indicate that a further investigation should be carried out and that some remedial work is needed. The major concerns of the overall integrity of the dam are as follows:

(1) The spillway can only pass 13 percent of the routed test flood outflow.

(2) There is minor seepage at locations along the downstream toe of the dam.

(3) The control of the outlet facilities downstream of the embankment results in the conduit being under continuous head.

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 earthdams to make investigations and studies of the following, and if proved necessary, to design appropriate remedial works.

(1) Make a detailed hydrologic-hydraulic investigation to access further the potential for overtopping and the adequacy of the spillway.

(2) Make a yearly evaluation of the seepage at the downstream toe of the dam.

(3) Perform a detailed analysis to provide means of positive closure on upstream end of conduit.

(4) Investigate whether spillway discharge channel modifications are required to forestall possible overtopping of the walls.

7.3 Remedial Measures

a. Operating and Maintenance Procedures

(1) Develop a formal surveillance and downstream emergency warning plan, including round-the-clock monitoring during periods of heavy precipitation.

(2) Institute procedures for an annual periodic technical inspection of the dam and dike and its appurtenant structures, including the minor seepage.

(3) Prepare a copy of the dam outlet control plan.

7.4 Alternatives

There appear to be no feasible alternatives to the above recommendations.

APPENDIX A

INSPECTION CHECKLIST

VISUAL INSPECTION CHECKLIST
PARTY ORGANIZATION

PROJECT LYNDE BROOK RESERVOIR DAM DATE 4/16/80

OWNER: CITY OF WORCESTER TIME 9:30 a.m.

WEATHER Cloudy

W.S. ELEV. 824.0 U.S. NA DN.S.

INSPECTION PARTY

PARTY:	A/E REPRESENTATIVES	OWNER'S REPRESENTATIVES
1.	Peter B. Dyson	Mike Pascal
2.	Pasquale E. Corsetti	Ed Foisy
3.	Roger F. Berry	
4.	Carl J. Hoffman	
5.	William S. Zoino	

	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 By 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 LYNDE BROOK RESERVOIR DAM DATE 4/16/80

PROJECT FEATURE EARTH EMBANKMENT NAME

DISCIPLINE GEOTECHNICAL NAME W. ZOINO

AREA EVALUATED	CONDITIONS
DAM EMBANKMENT SOUTH DAM	
Crest Elevation	827.5
Current Pool Elevation	824.0
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	Good
Indications of Movement of Structural Items on Slopes	None
Trespassing on Slopes	None
Sloughing or Erosion of Slopes or Abutments	None
Rock Slope Protection - Riprap Failures	Good condition
Unusual Movement or Cracking at or near Toes	None
Unusual Embankment or Downstream Seepage	2 minor seeps less than 0.1 gpm at toe
Piping or Boils	None
Foundation Drainage Features	None evident
Toe Drains	None evident
Instrumentation System	None evident

PERIODIC INSPECTION CHECKLIST

PROJECT LYNDE BROOK RESERVOIR DAM DATE 4/16/80

PROJECT FEATURE EARTH EMBANKMENT NAME W. Zoino

DISCIPLINE GEOTECHNICAL NAME

AREA EVALUATED	CONDITIONS
DIKE EMBANKMENT EAST DIKE	
Crest Elevation	827.35
Current Pool Elevation	824.0
Maximum Impoundment to Date	Unknown
Surface Cracks	None
Pavement Condition	N/A
Movement or Settlement of Crest	None
Lateral Movement	None
Vertical Alignment	Good
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Good
Indications of Movement of Structural Items on Slopes	None
Trespassing on Slopes	None
Sloughing or Erosion of Slopes or Abutments	None
Rock Slop Protection - Riprap Failures	Small sized 6"-12", but in good condition.
Unusual Movement or Cracking at or near Toes	None
Unusual Embankment or Downstream Seepage	None
Piping or Boils	None evident
Foundation Drainage Features	None evident
Toe Drains	None evident
Instrumentation System	None evident

PERIODIC INSPECTION CHECKLIST

PROJECT LYNDE BROOK RESERVOIR DAM DATE 4/16/80

PROJECT FEATURE OUTLET CONTROL STRUCTURES NAME

DISCIPLINE STRUCTURAL NAME C. HOFFMAN

AREA EVALUATED	CONDITIONS	
OUTLET WORKS - CONTROL TOWER	CONTROL HOUSE AT TOE OF SO. DAM	CONTROL TOWER AT EAST DIKE
a. Concrete and Structural		
General Condition	Good	Good
Condition of Joints	Good	Good
Spalling	None	None
Visible Reinforcing	None	None
Rusting or Staning of Concrete	None	None
Any Seepage or Efflorescence	None	None
Joint Alignment	Good	Good
Unusual Seepage or Leaks in Gate Chamber	None evident	Unknown
Cracks	None	None
Rusting or Corrosion of Steel	Minor on gate stems	None
b. Mechanical and Electrical	N/A	N/A
Air Vents		
Float Wells		
Crane Hoist		
Elevator		
Hydraulic System		
Service Gates		
Emergency Gates		
Lighting Protection System		
Emergency Power System		
Wiring and Lighting System in Gate Chamber		

PERIODIC INSPECTION CHECKLIST

PROJECT LYNDE BROOK RESERVOIR DAM DATE 4/16/80

PROJECT FEATURE Spillway NAME

DISCIPLINE Structures NAME C. Hoffman

AREA EVALUATED	CONDITIONS
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	
General Condition	Good
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	None
Floor of Approach Channel	Paved
b. Weir and Training Walls	
General Condition of Concrete	Good
Rust or Staining	Minor
Spalling	None
Any Visible Reinforcing	None
Any Seepage or Efflorescence	Minor
Drain Holes	N/A
c. Discharge Channel	
General Condition	Good
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	None
Floor of Channel	Paved
Other Obstructions	None

PERIODIC INSPECTION CHECKLIST

PROJECT LYNDE BROOK RESERVOIR DAM DATE 4/16/80

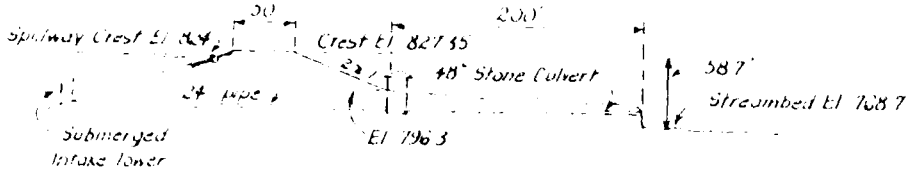
PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

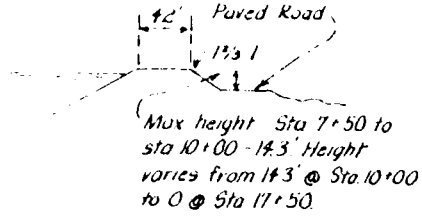
AREA EVALUATED	CONDITIONS
Outlet Works - Intake Channel and Intake Structure	N/A
Outlet Works - Transition & Conduit	N/A
Outlet Works - Outlet Structure and Outlet Channel	N/A
Outlet Works - Service Bridge	N/A

APPENDIX B

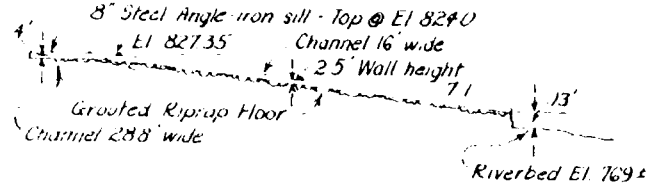
ENGINEERING DATA



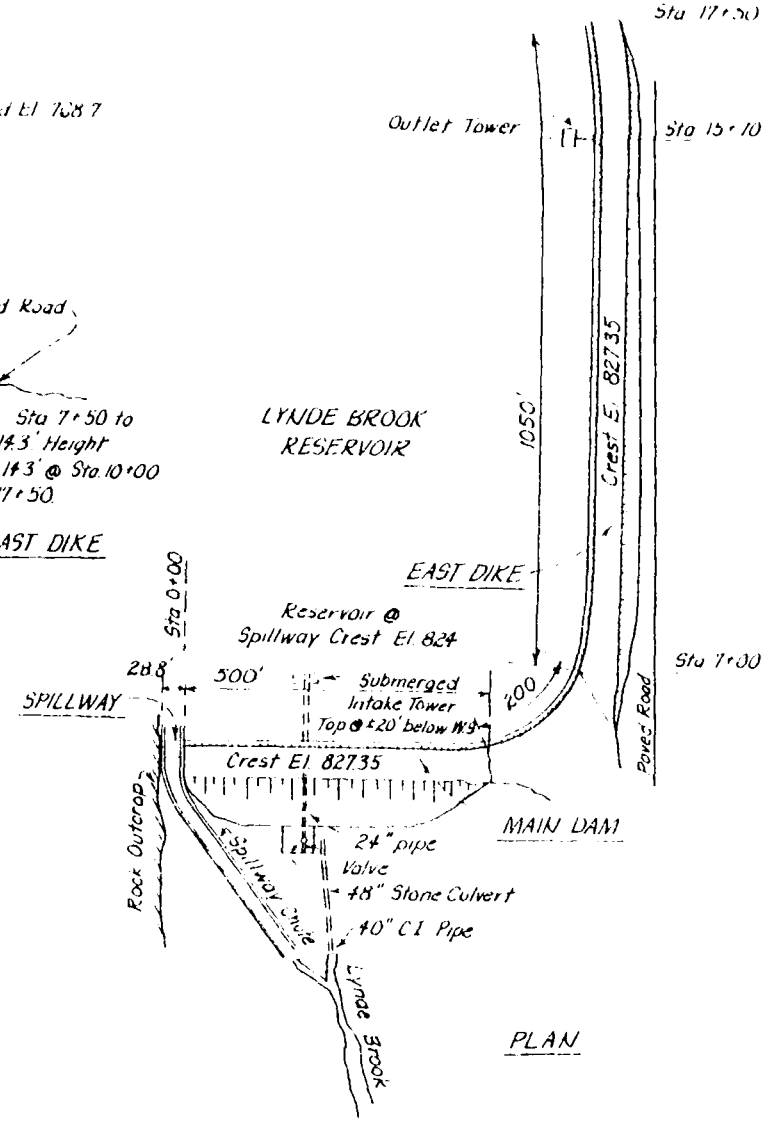
SECTION THRU MAIN DAM



SECTION THRU EAST DIKE



SPILLWAY PROFILE



PLAN

LYNDE BROOK RESERVOIR DAM

COUNTY OF WORCESTER MASSACHUSETTS

COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs.

Inspected by K. M. Finlayson Date 4-15-37 Dam No. 25-25

Town Leicester Location Lynds Brook Res.

Owner 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 OK

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 OK

GATES Location

Size Kind El. Flowline

Condition OK

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 of 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 LCW-L.Goodale-L.Lingley Date Nov.19,1929 , Dam No. 25-25

Town Leicester Location

Owner 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 OK, except abutment walls will have to be rebuilt acct frost action etc.-to be done 1930.

EMBANKMENT

El. Top El. Natural Ground Width Top

Width of Bottom Upstream Slope Downstream Slope

Kind of Corewall Riprap

Material in Embankment Foundation

Condition OK

GATES Location

Size Kind El. Flowline

Condition OK

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

B-7

TOWN OR CITY Leicester DECREE NO. 262. PLAN NO. DAM NO. 25-25

LOCATION C. C. DOCKET NO.

DESCRIPTION OF DAM

Type Earth- concrete core wall
Length
Height 40'
Thickness top 50'
" bottom 240'
Downstream Slope 2:1
Upstream " 2:1 rip-rap
Length of Spillway
Size of Gates 3-24" Pipes
Location of Gates Upstream left
Flashboards used
Width Flashboards or Gates
Dam designed by Wm. J. McAlpine 1876
" constructed by
Year constructed

GENERAL REMARKS

Owned by City of Worcester. Water Dept
Vol. 26. P. 102. Oct. 9. 1877.
" 25. P. 366. May 25, 1876.
" 25 - P. 391 - April 17, 1876.
Specifications for repairs - March meeting 1876

DESCRIPTION OF RESERVOIR & WATERSHED

Name of Main Stream Lynde Brook
" " any other Streams
Length of Watershed
Width " "
Is Watershed Cultivated
Percent in Forests
Steepness of Slope
Kind of Soil
No. of Acres in Watershed
" " " " Reservoir 132.
Length of Reservoir
Width " "
Max Flow Cu. Ft. per Sec.
Head of Flashboards Low Water
" " " High "

Traced by: K M Finlayson
Checked by: L. O. M.

GENERAL REMARKS

L. O Marden

Inspected: Dec 7, 1928 " " "
" : Nov. 19, 1929 [illegible]
" : Aug. 24, 1932 - " "
" : April 15, 1937 - K. M. Finlayson
" : Oct. 13, 1938 - L. H. Spofford
" : Dec. 10, 1940 - " " "
" " Sept. 16, 1943 - L.O.M - C. Perry - Starbard

Inspected: Dec. 10, 1945 - M.F. Hoar
" Nov. 18, 1947 - E. Perry - L.O.M - Hardy
" Jan. 7, 1953 - L.H. Spofford & Lloyd Starbard
" May 25, 1960 - LOM - Starbard

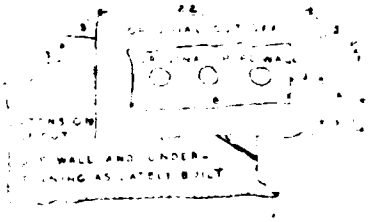
25-25

BOARD OF COUNTY COMMISSIONERS
ENGINEERING DEPARTMENT
PLAN OF
DAM
WORCESTER, MASS
COUNTY OF WORCESTER
APPROVED BY THE
COUNTY COMMISSIONERS
MEETING DOCKET
DAM NO. 5-25

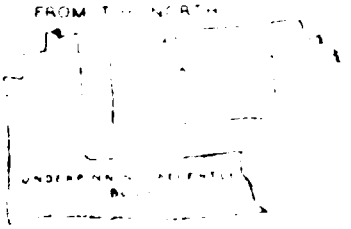
13

SCALE 9FEET TO AN INCH
DRAWN FROM RECOLLECTION WITHOUT ANY
MEASUREMENTS BEFOR ME
ENGR WJM

ELEVATION OF
CUT OFF NO 2
VIEW FROM THE SOUTH



ELEVATION OF
CUT OFF NO 4
FROM THE NORTH



ELEV
WITH
INSPECT

NOTE

THE NEW MASONRY PROPOSED BY THE INSPECTORS FOR THE EAT
OF THE CUT OFF ON THE LINE OF CUT OFF NO 3 IS DRAWN 6
WIDE AND I HAVE ADDED AT THE END THERE OF A FACE WALL
5 FEET THICK UNDERPINNING THE PIPE WALL
ALSO TWO WING WALLS OF 6 FEET LONG AND 2 FEET THICK TO
THE CONNECTION WITH THE THE EAST PUDDLE WALL SAFER
ALL THE OTHER WORK SHOWN ON THIS PLAN MUST BE DONE
ADDITION TO THE WORK PROPOSED BY THE INSPECTORS

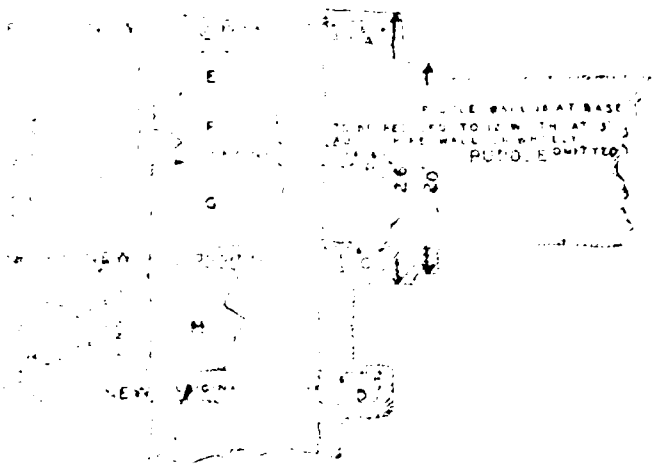
BABYLON AUGUST 22,
WM J. McA
CONSULT
ENGINE

2

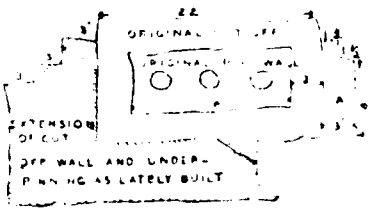
PLAN
AUGUST [illegible] 87[illegible]
[illegible]ST JOHN[illegible]IANA
ASST [illegible]ER[illegible]

SCALE 9FEET TO
DRAWN FROM RECOLLECTIO
MEASUREMENTS HEI

ORIGINAL
[illegible]FE WALL
16 WIDE



ELEVATION OF
CUT OFF NO 2
VIEW FROM THE SOUTH



ELEVAT
CUT O
FROM

NOTE

[illegible]NGEMENT OF THE PUDDLING AND OF
[illegible]ONS MUST BE STRICTLY ADHERED TO
[illegible]ASTLY MORE CONSEQUENCE THAN THE
[illegible] WHICH THE MASONRY ON THE
[illegible] EXTENDED AT THIS PLACE

THE NEW MASONRY PROPOSE
OF THE CUT OFF ON THE
WIDE AND I HAVE ADDED A
5 FEET THICK UNDERPINNIN
ALSO TWO WING WALLS OF
THE CONNECTION WITH TH
ALL THE OTHER WORK SH
ADDITION TO THE WORK

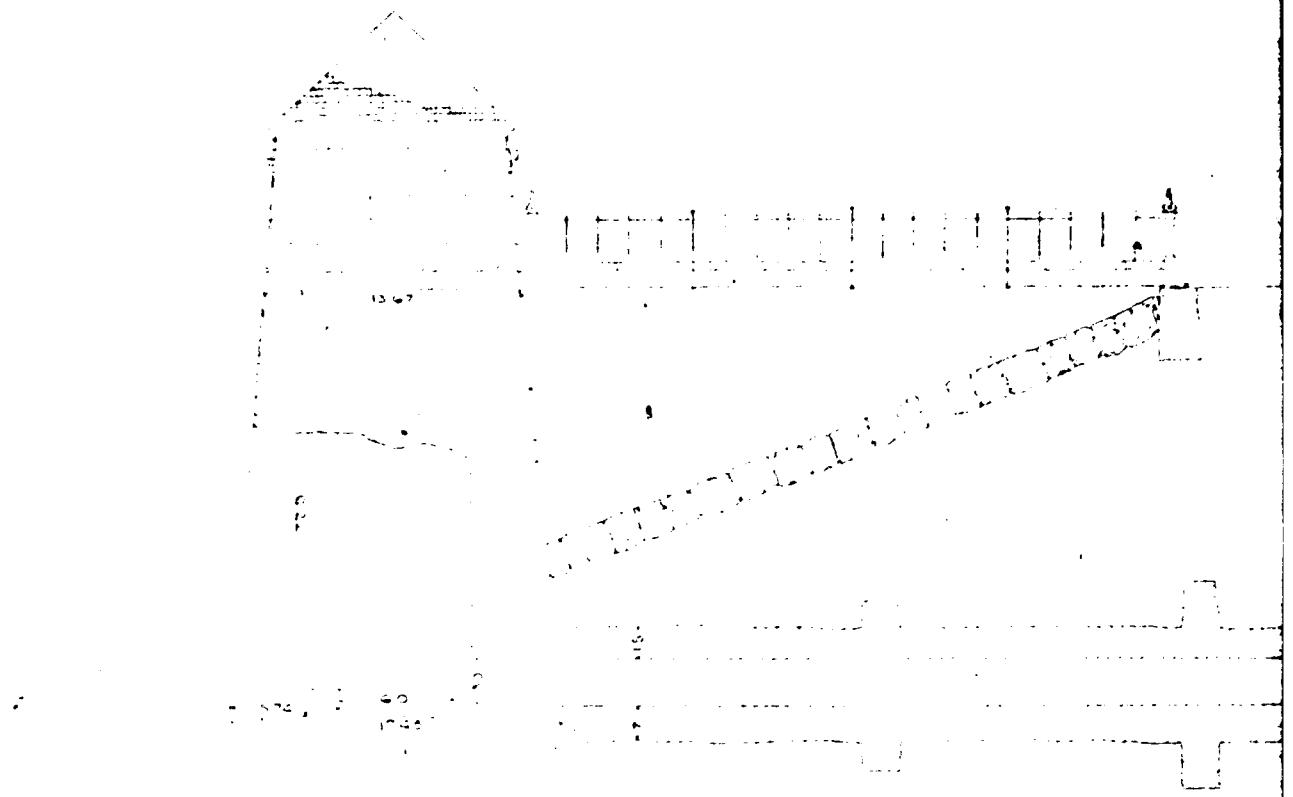
NOTE

B C AND D SHOW EXTENSION OF ORIGINAL
[illegible] OFFS ORDERED BY W J M
F G AND H NEW UNDERPINNING OF
[illegible]E WALL RECENTLY BUILT
MASONRY WH[illegible] HAS BEEN PUT IN
[illegible] THE WEST SIDE OF THE
WALL IS SHADED WITH LINES

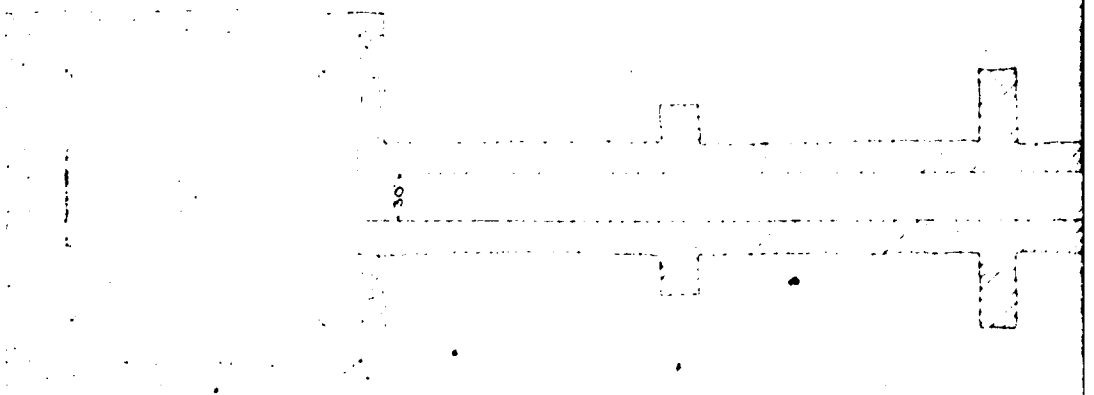
COUNTY COMMISSIONERS

3

B-4



SCALE 1 60



COMMISSIONERS

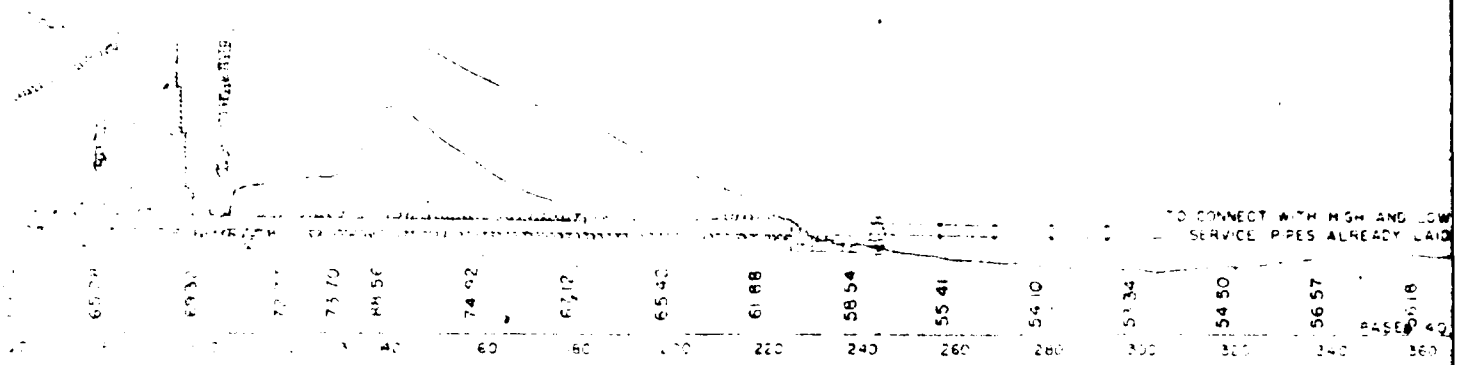
DAM NO 25-25

COUNTY ENGINEER

3

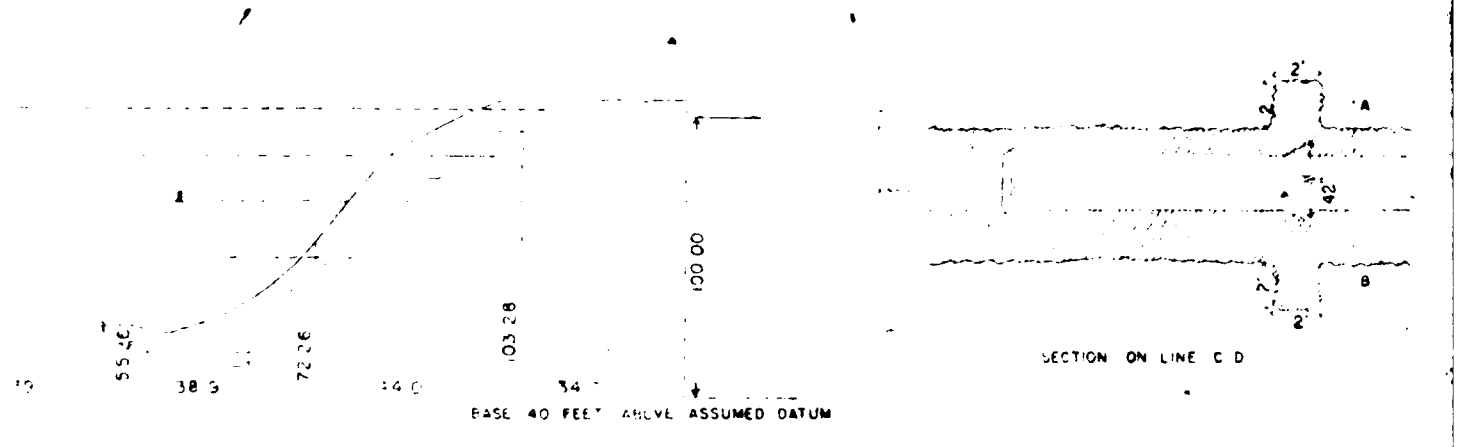
SECTIONS SHOWING PROPOSED METHOD OF

DAM AT LYNDE BROOK RESERVOIR



SECTION THROUGH PROPOSED PIPE LINE

NO 1



SECTION THROUGH PROPOSED PUDDLE WALL

NO 2

DETAILS SHOWING CUT

NO 3

SCALE 1 INCH = 8 FEET

NO 3 & 4

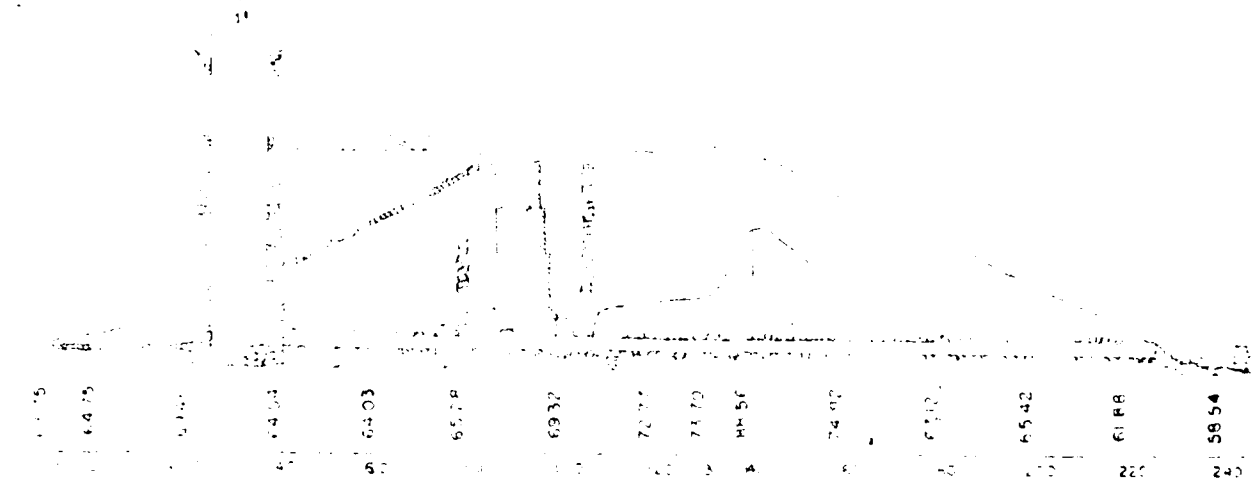
SURVEYED BY A. FARMEN APRIL 7, 1876

APPROVED AND ADOPTED BY THIS BOARD,

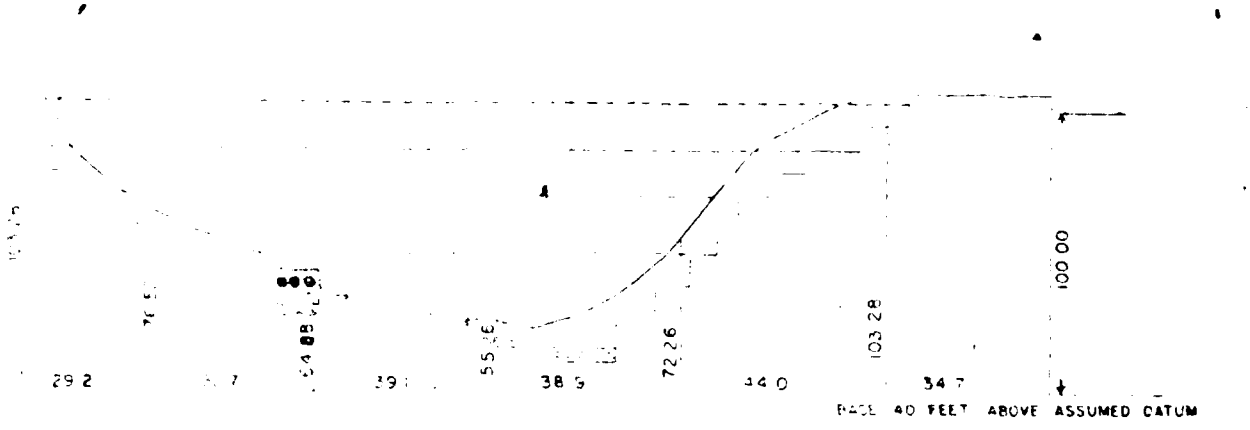
CHIEF ENGINEER

CHARLES SMITH CLERK OF COMMON COUNCIL

2



SECTION THROUGH PROPOSED PIPE LINE
NO 1

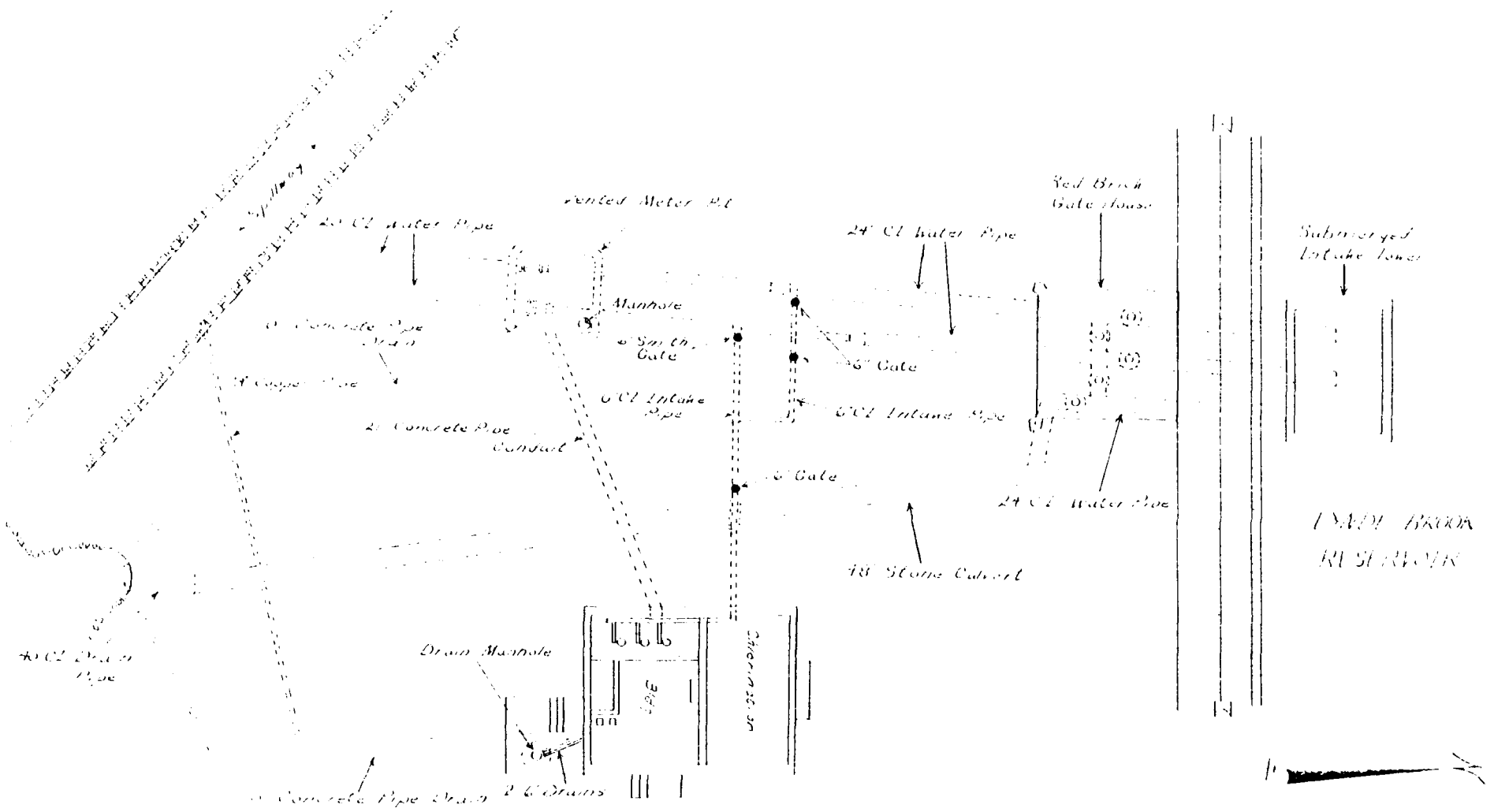


SECTION THROUGH PROPOSED PUDDLE WALL
NO 2

CITY ENGINEER

CONSULTING ENGINEER

BOARD OF ALDERMEN APRIL 1876
APPROVED AS ADOPTED BY THIS BOARD.
SENT DOWN FOR CONCURRENCE
SAMUEL SMITH CLERK IN COMMON COUNCIL
CONCURRED
HAMILTON E FLECK
APPROVED APRIL 1876
CLARK JILLSON MAYOR



SKETCH OF OUTLET CONTROL

COUNTY OF WORCESTER MASSACHUSETTS
COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs.

Inspected by L H Spofford Date Oct 13 1938 Dam No. 25-25

Town Lancaster Location Lynde Brook Reservoir

Owner Worcester Water Dept Use Water Supply

Material and Type Earth Embankment.

Dam Designed by Constructed by Year

1- SPILLWAY Grouted Ston 30' lg x 4' ~~high~~ uniform thkn. side walls

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 Excellent - Information from caretaker is that flood was two feet over the crest of the spillway.

EMBANKMENT

El. Top El. Natural Ground Width Top

Width of Bottom Upstream Slope Downstream Slope

Kind of Corewall Riprap

Material in Embankment Foundation

Condition Excellent - no seepage or damage.

GATES 2 cis in gate houses. 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

COUNTY OF WORCESTER MASSACHUSETTS

COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs.

Inspected by J. H. Spafford Date Dec 10 | 40 Dam No. 25-25

Town Leicester Location Lyles Brook Reservoir

Owner City of Worcester Water Dept Use

Material and Type Earth Embankment

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 Excellent

EMBANKMENT

El. Top El. Natural Ground Width Top

Width of Bottom Upstream Slope Downstream Slope

Kind of Corewall Riprap

Material in Embankment Foundation

Condition Excellent

GATES Location In Gate House

Size Kind El. Flowline

Condition

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-0

WORCESTER COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs

Inspected by Lon - E. Perry - L. Hartwell Date 9-16-43 Dam No. 25-25

Town ~~Leicester~~ Leicester Location Lynde Br.

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 OK

EMBANKMENT

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

Width of Bottom _____ Upstream Slope _____ Downstream Slope _____

Kind of Corewall _____ Riprap _____

Material in Embankment _____ Foundation _____

Condition OK

GATES _____ Location _____

Size _____ Kind _____ El.Flowline _____

Condition OK

Evidence of Leaks in Structure OK

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~~ 90 Feet 70

COUNTY OF WORCESTER MASSACHUSETTS

COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs.

Inspected by M.F. Hunt Date Dec. 12 1945 Dam No. 25-25

Town Leicester Location Linda Brook Rd

Owner City of Worcester Water Dept Use

Material and Type

Dam Designed by Constructed by Year

RECEIVED DEC 11 1945 WORCESTER COUNTY ENGINEERING DEPT.

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 O.K.

EMBANKMENT

El. Top El. Natural Ground Width Top

Width of Bottom Upstream Slope Downstream Slope

Kind of Corewall Riprap

Material in Embankment Foundation

Condition O.K.

GATES Location

Size Kind El. Flowline

Condition O.K.

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

B-12

TOWN Leicester DAM NO. 25-25

LOCATION Lynde Brook Res. STREAM Lynde Br.

WORCESTER COUNTY ENGINEERING DEPARTMENT

WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

OWNED BY Worcester Water Dept. PLACE Worcester USE storage

INSPECTED BY E.Perry-Hardy-Marden DATE Nov.18,1947.

TYPE OF DAM Earth emb..stone spillway 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

REPAIRS NEEDED none

LEAKS

HOW SERIOUS none visible.

DATE Feb.6,1947

L. O. Hardy
COUNTY ENGINEER

TOWN Lancaster

LOCATION Lyndes Brook

DAM NO. 25-25

STREAM

WORCESTER COUNTY ENGINEERING DEPARTMENT

WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

OWNED BY City of Worcester PLACE USE Reservoir

INSPECTED BY Lt Spofford + Lloyd Stafford Jan 7 1953

TYPE OF DAM Earth CONDITION Excellent

SPILLWAY

FLASHBOARDS IN PLACE None RECENT REPAIRS None

CONDITION Excellent

REPAIRS NEEDED None

EMBANKMENT

RECENT REPAIRS None

CONDITION Excellent

REPAIRS NEEDED None.

GATES

RECENT REPAIRS None

CONDITION Excellent

REPAIRS NEEDED None

LEAKS

HOW SERIOUS None.

DATE 1/7/53

COUNTY ENGINEER

TOWN Leicester DAM NO. 25-25

LOCATION Lynde at Reservoir St STREAM Lynde Brook

"Lynde Brook Res"

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 City of Worcester Place Water Dept Use Water Supply

Inspected by WCC Date 9-13-55

Type of Dam Earth - Stone Condition Good

SPILLWAY

Flashboards in Place No boards Recent Repairs _____

Condition Water level is 1' below crest of spillway

Repairs Needed Minor washouts in downstream paved channel

EMBANKMENT

Recent Repairs _____

Condition Good

Repairs Needed _____

GATES

Recent Repairs _____

Condition Good

Repairs Needed _____

LEAKS

How Serious No leaks

DATE: _____ County Engineer

TOWN Leicester DAM NO. 25-25

LOCATION Lynde Brook Res STREAM

WORCESTER COUNTY ENGINEERING DEPARTMENT

WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

OWNED BY W. W. D PLACE Wore USE Water supply

INSPECTED BY LOM DATE May 8, 1957

TYPE OF DAM Earth stone CONDITION

SPILLWAY

FLASHBOARDS IN PLACE None RECENT REPAIRS

CONDITION Good

REPAIRS NEEDED None

EMBANKMENT

RECENT REPAIRS None

CONDITION Good

REPAIRS NEEDED None

GATES

RECENT REPAIRS Nac

CONDITION Good

REPAIRS NEEDED None

LEAKS

HOW SERIOUS None visible

DATE May 8. 1957

L. O. Ward
COUNTY ENGINEER

TOWN Leicester DAM NO. 25-25

LOCATION Lynde Brook STREAM Lynde Brook

WORCESTER COUNTY ENGINEERING DEPARTMENT

WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

OWNED BY W.W.D. PLACE Wach USE Dr. H2O

INSPECTED BY LOM DATE May 8, 1957

TYPE OF DAM Earth - Masonry CONDITION Good

SPILLWAY

FLASHBOARDS IN PLACE — RECENT REPAIRS None

CONDITION Good

REPAIRS NEEDED None

EMBANKMENT

RECENT REPAIRS None

CONDITION Good

REPAIRS NEEDED None

GATES

RECENT REPAIRS None

CONDITION Good

REPAIRS NEEDED None

LEAKS

HOW SERIOUS None

DATE May 8, 1957

L.O. Marde
COUNTY ENGINEER

TOWN Leicester DAM NO. 25-25

LOCATION Lynde Brook Rd 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 Bureau of H2O Works Place Use

Inspected by L. Stafford - L.O.M Date 5-25-61

Type of Dam Condition Good

SPILLWAY

Flashboards in Place Recent Repairs

Condition Good

Repairs Needed None

EMBANKMENT

Recent Repairs None

Condition Good

Repairs Needed

GATES

Recent Repairs None

Condition Gates in Gate House

Repairs Needed None

LEAKS

How Serious

DATE: May 25, 1961

L.O. Marden
County Engineer

B-8

TOWN Leicester DAM NO. 25-25

LOCATION Reservoir Road STREAM Lynde Brook

Lynde Brook Reservoir

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by City of Worcester Place Water Dept Use Water Supply

Inspected by WRL Date Nov. 5, 1963

Type of Dam Earth, stone and concrete Condition Good

SPILLWAY

Flashboards in Place _____ Recent Repairs _____

Condition Good

Repairs Needed _____

EMBANKMENT

Recent Repairs This reservoir is now dry - this reservoir has not

Condition been used for a few years due to the silting and

Repairs Needed discoloration of this stream on account of the new construction at the Worcester Municipal Airport.

GATES

Recent Repairs _____

Condition Good

Repairs Needed _____

LEAKS

How Serious _____

DATE: _____ County Engineer

TOWN Leicester DAM NO. 25-25

LOCATION Lynde Brook Rd STREAM

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by Place Use

Inspected by Date

Type of Dam Condition

SPILLWAY

Flashboards in Place Recent Repairs

Condition Level & good crest

Repairs Needed

EMBANKMENT

Recent Repairs

Condition

Repairs Needed

GATES

Recent Repairs open

Condition

Repairs Needed

LEAKS

How Serious

DATE: March 1962

County Engineer

APPENDIX C

PHOTOGRAPHS

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

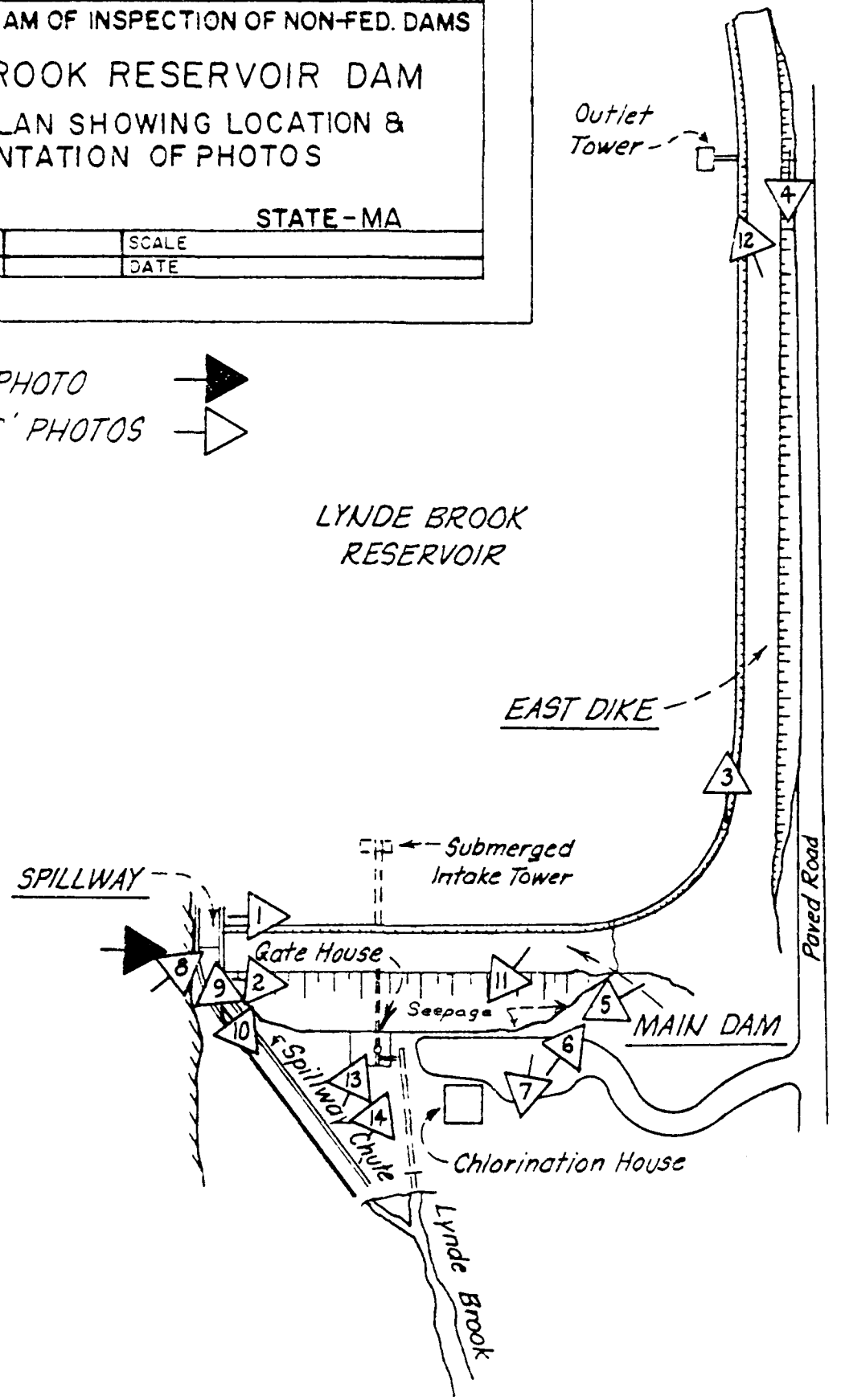
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LYNDE BROOK RESERVOIR DAM

SKETCH PLAN SHOWING LOCATION & ORIENTATION OF PHOTOS

STATE - MA

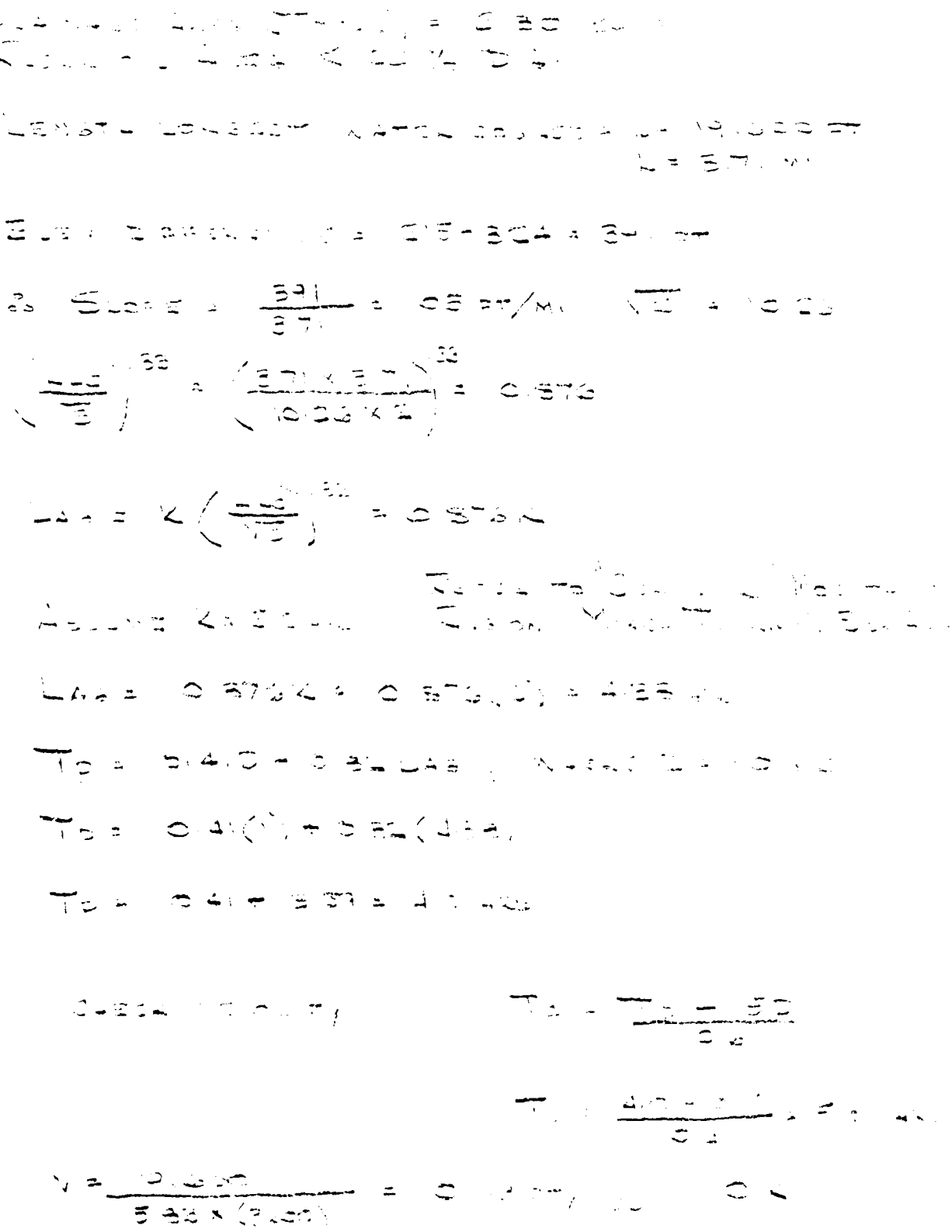
			SCALE
			DATE

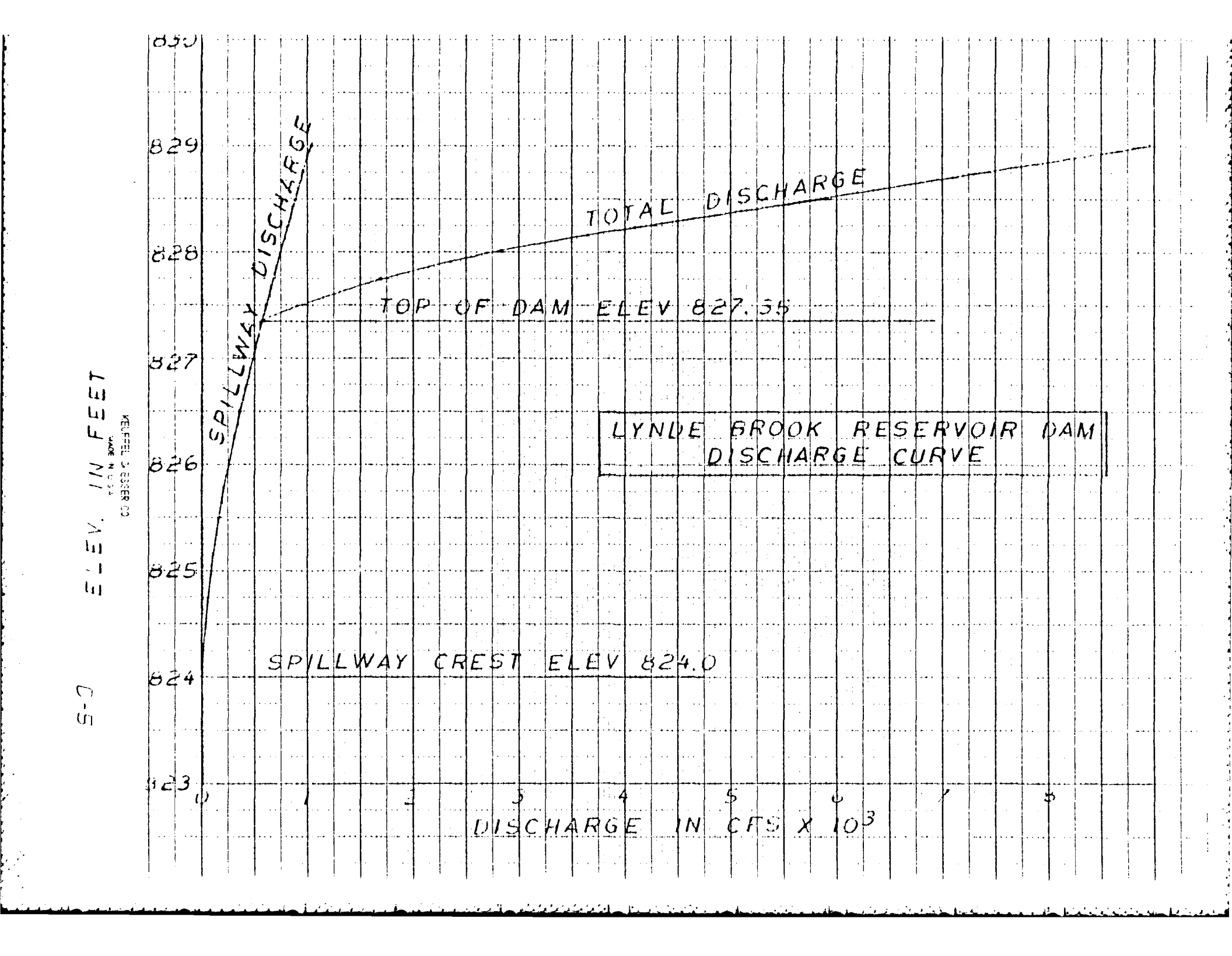


BY _____ DATE _____ **LOUIS BERGER & ASSOCIATES INC.** SHEET NO _____ OF _____

CHKD. BY _____ DATE _____ PROJECT _____

SUBJECT _____



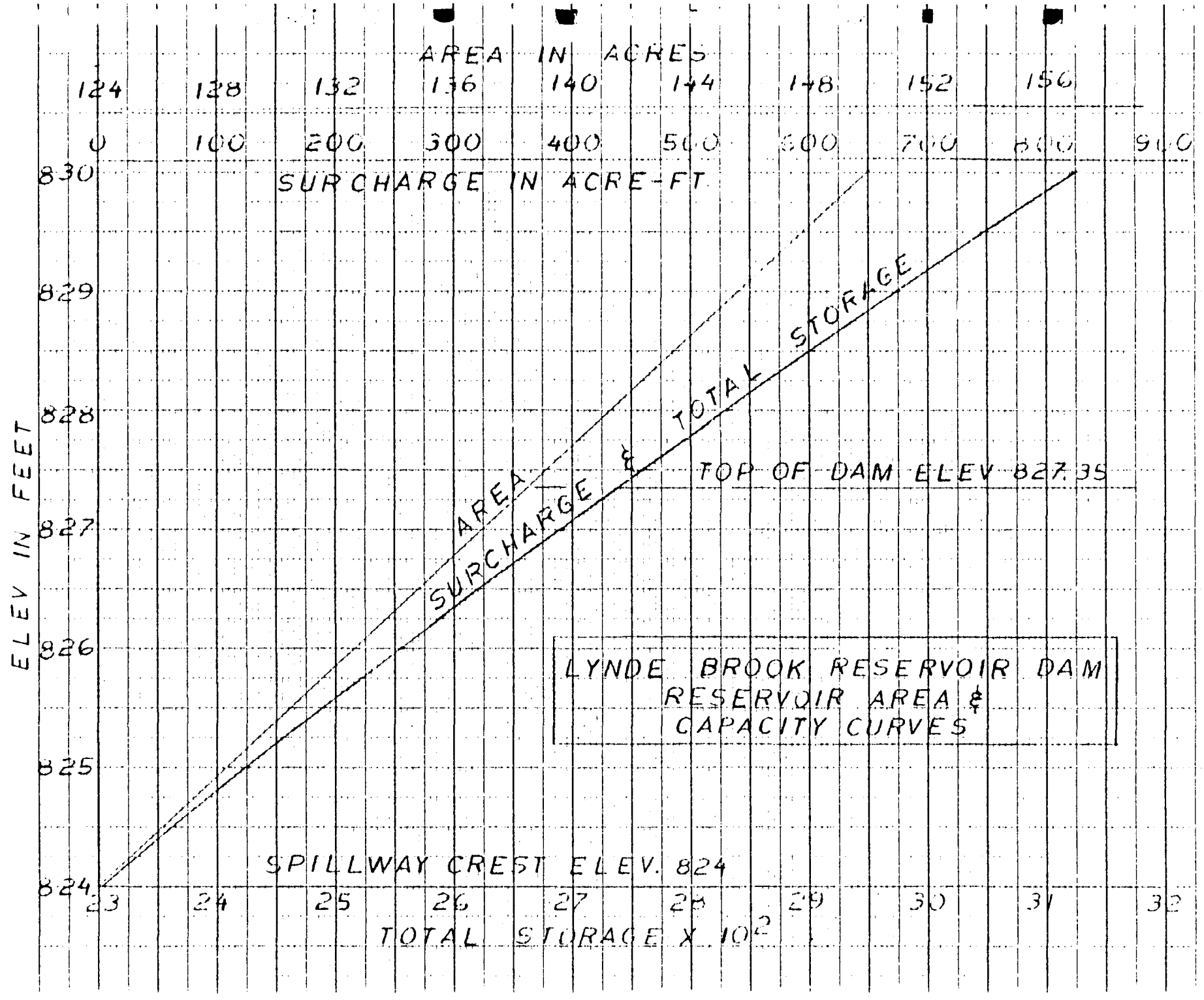

ELEV. IN FEET
829
828
827
826
825
824
823
SPILLWAY DISCHARGE
TOTAL DISCHARGE
TOP OF DAM ELEV 827.35
LYNDE BROOK RESERVOIR DAM
DISCHARGE CURVE
SPILLWAY CREST ELEV 824.0
0
1
2
3
4
5
6
7
8
DISCHARGE IN CFS X 10³

BY _____ DATE _____ **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. _____ OF _____

CHKD. BY _____ DATE _____ PROJECT _____

SUBJECT _____

D - 4


AREA IN ACRES
124
128
132
136
140
144
148
152
156
0
100
200
300
400
500
600
700
800
900
SURCHARGE IN ACRE-FT
830
829
828
827
826
825
824
ELEV IN FEET
AREA
SURCHARGE & TOTAL STORAGE
TOP OF DAM ELEV 827.35
LYNDE BROOK RESERVOIR DAM
RESERVOIR AREA &
CAPACITY CURVES
SPILLWAY CREST ELEV. 824
23
24
25
26
27
28
29
30
31
32
TOTAL STORAGE X 10²

BY SFB DATE [illegible] LOUIS BERGER & ASSOCIATES INC. SHEET NO ____ OF ____

CHKD. BY ____ DATE ____ [illegible] PROJECT [illegible]

SUBJECT [illegible]

[illegible] = 124 Acres

[illegible] H = 824' - 784' = 50 ft

Volume at El. 824 = 124 x 50 x 1/3 = 2073 Acre-ft

Old Inventory Gives Volume = 2400 Acre-ft

Say Natural Volume = 2300 Acre-ft

El. Ft	Area	Ave Area	ΔH	Δ Storage	Total Storage	Storage Curve
824	124				2073	0
825	128.2	126.15	1	126.1	2199	126
826	130.7	129.5	1	129.5	2329	256
827	137	133.85	1	133.8	2463	390
828	141.2	139.15	1	139.1	2602	529
829	145.7	143.5	1	143.5	2746	673
830	150	147.85	1	147.9	2894	821

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

CHKD. BY [illegible] DATE [illegible] PROJECT [illegible]

SUBJECT [illegible]

FIND DRAINAGE AREA

READ = 2 32.10
1 = 1 12.54
19.54

READ = 2 51.65
1 = 1 32.9
18.75

DRAINAGE AREA = 19.545 (0.1459) = 2.80 SQ MI = 1792 ACRES

RESERVOIR SURFACE AREA, ELEV. 820

READ = 2 50.66
1 = 1 51.29
1.37

READ = 2 53.44
1 = 1 52.06
1.38

RESERVOIR AREA = 1.35 x 91.83 = 124 ACRES

AREA @ ELEV. 830

READ = 2 55.60
1 = 1 53.99
1.61

READ = 2 57.26
1 = 1 55.60
1.66

AREA @ ELEV. 830 = 1.635 (91.83) = 150 ACRES

AREA @ ELEV. 840

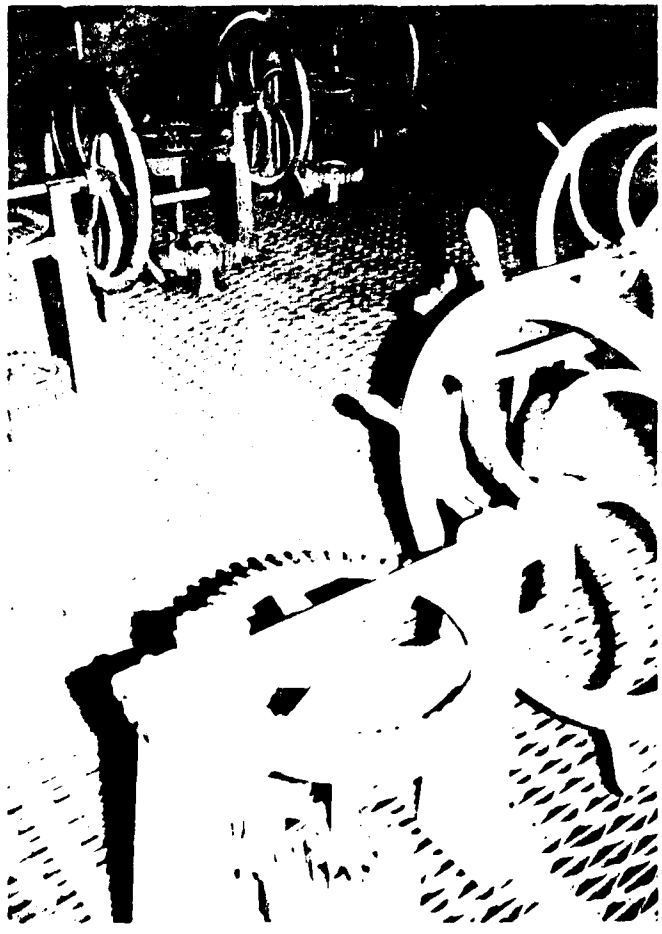
READ = 2 59.22
1 = 1 57.28
2.06

READ = 2 61.36
1 = 1 59.32
2.04

AREA @ ELEV. 840 = 2.05 (91.83) = 188 ACRES

APPENDIX D

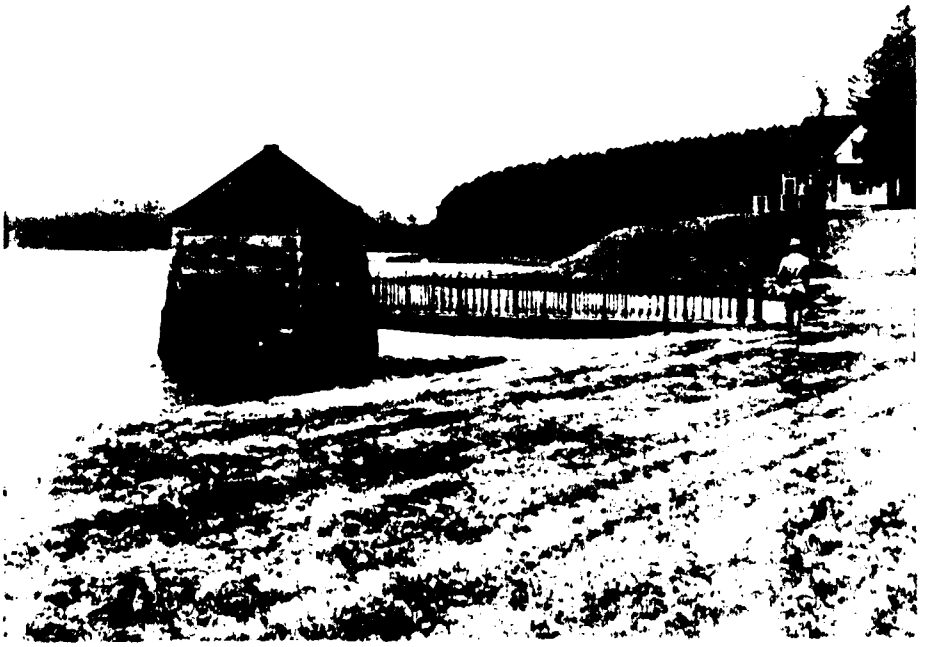
HYDROLOGIC AND HYDRAULIC COMPUTATIONS



13. Manual operating mechanisms in first floor of gate house at downstream toe of dam.

14. Outlet pipes, valves and stems in basement of gate house at downstream toe of dam.

11. Outlet gate house on right and chlorination building on left at downstream toe of dam.

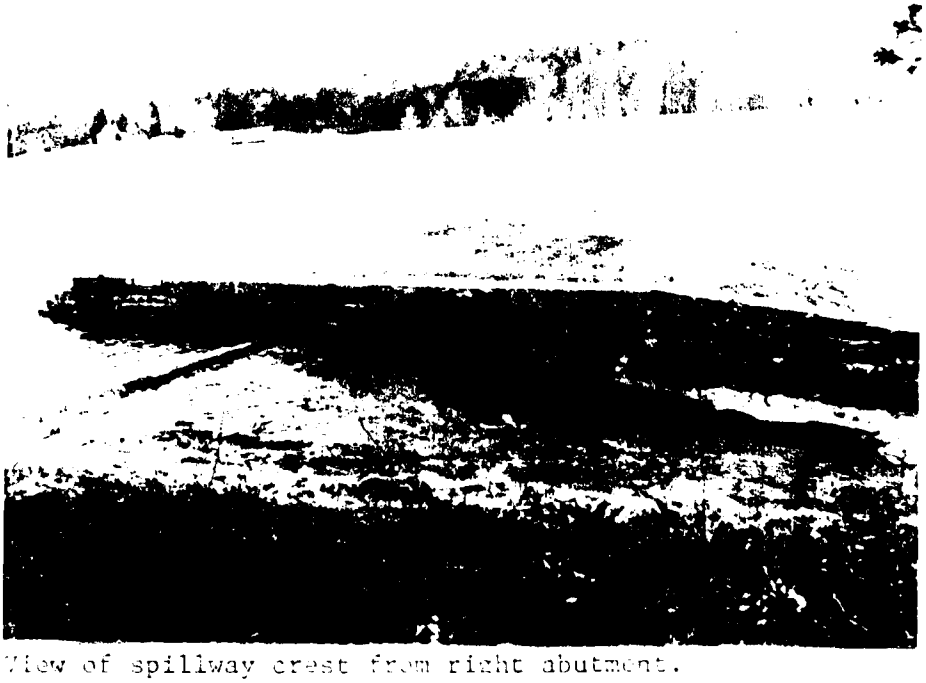


12. [illegible] house at northerly end of [illegible]

9. Spillway training walls and angle iron sill

10. Downstream spillway channel

7. Seepage on south side of roadway along downstream toe of dam.



8. View of spillway crest from right abutment.

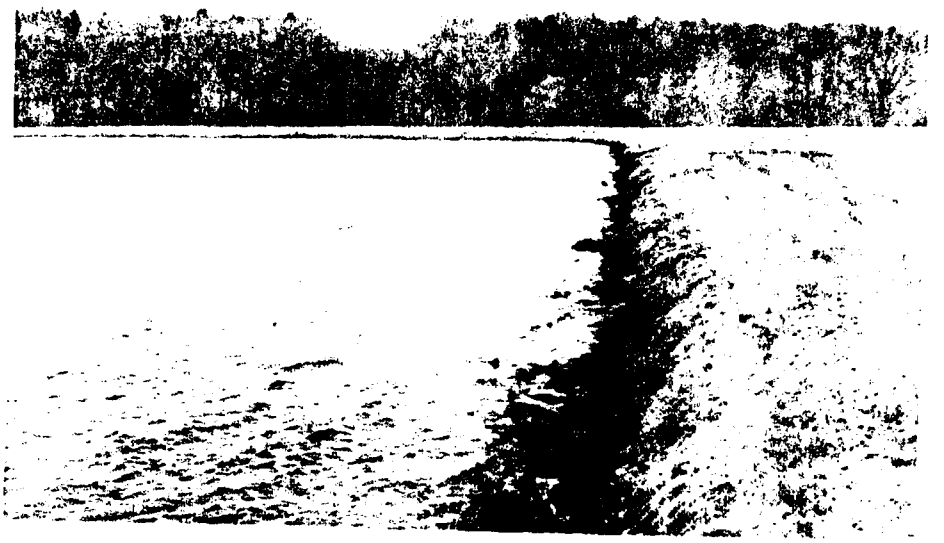
5. Seepage at downstream toe of dam

6. Seepage at junction of dam and left abutment

3. Upstream slope of East Dike

4. Downstream slope of East Dike

LINDE BROOK RESERVOIR DAM



1. Upstream slope of dam

2. Downstream slope of dam

BY _____ DATE _____ **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. _____ OF _____

CHKD. BY _____ DATE _____ PROJECT _____

SUBJECT _____

T_C = [illegible]

T_L = [illegible]

q_p = PEAK RATE IN CFS

$q_p = \frac{484 A}{T_p}$ A = DRAINAGE AREA
Q = RUNOFF IN INCHES

$q_p = \frac{484 (2.80)(1)}{4.0} = 339$ CFS

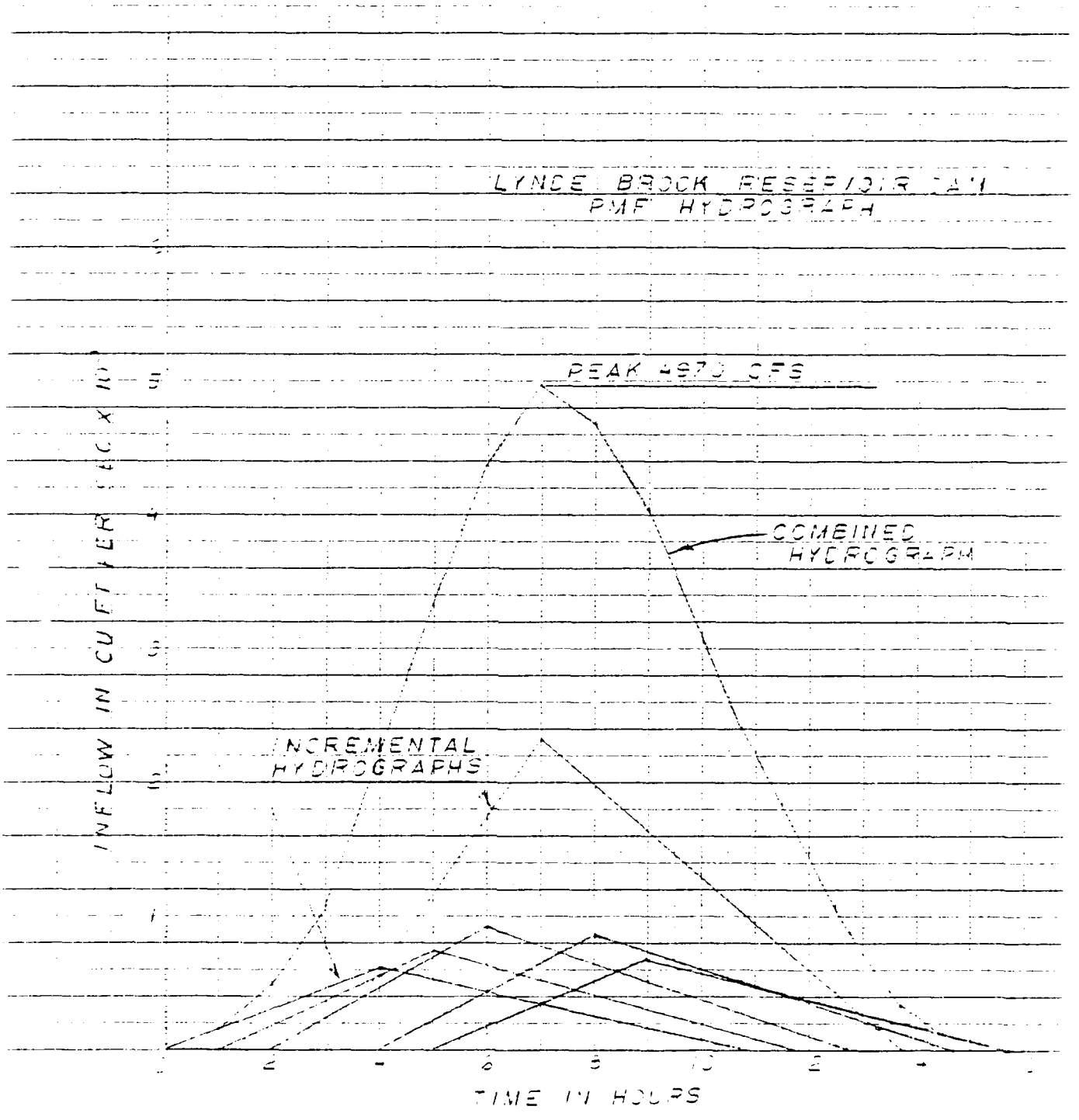
PMP = PROBABLE MAXIMUM PRECIPITATION

= 28" (0.2) = 18.1" FOR WATERSHED

= 18" ADJUSTED FOR SIZE OF WATERSHED

OVER 1 SQ. MI.

TIME (HOURS)	RAINFALL % PMP	RAINFALL INCHES	Q CFS	TIME BEGIN	TIME END	TIME END
0.0						
1.0	0	1.80	4.0	0	40	107
2.0	2	2.14	732	10	50	107
3.0	5	2.70	915	20	60	107
4.0	38	6.84	2315	30	70	21
5.0	4	2.52	854	40	80	47
6.0	1	1.80	610	50	90	57


LYNCE BROOK RESERVOIR DAM
PMF HYDROGRAPH
PEAK 4970 CFS
COMBINED HYDROGRAPH
INCREMENTAL HYDROGRAPHS
INFLOW IN CUBIC FEET PER SECOND (CFS X 10)
TIME IN HOURS

BY ____ DATE ____ **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. ____ OF ____

CHKD. BY ____ DATE ____ PROJECT ____

SUBJECT ____

Drainage Area = 2.80 sq.mi. = 1792 Acres

Maximum Storage = 2787 Acre-ft

Height to Spillway Crest = 31.0 - 7.0 = 24.0 ft

Dam Classification: Intermediate

Hazard Classification: High
Use Probable Maximum Flood

From HEC-1 Hydrograph, Q_{PMF} = 4,970 cfs

Step 1: Q_{P1} = 4,970

Step 2a: Elev. = 808.37

Step 2b: Surcharge Volume = 750 Acre-ft

Inches of Runoff = $\frac{550 \text{ Acre-ft}}{1792 \text{ Acres}} \times 12 \text{ in/ft} = 3.68$ in

Step 2c:

$$Q_{P2} = 4970 \times \left(1 - \frac{3.68}{19}\right)$$

$$= 3955 \text{ cfs}$$

Step 3: For Q = 3955

Surcharge Height = 808.37 - 783.0 = 25.37 ft

Surcharge Volume = 560 Acre-ft

BY ___ DATE ___ LOUIS BERGER & ASSOCIATES INC. SHEET NO ___ OF ___

CHKD. BY ___ DATE ___ PROJECT ___

SUBJECT ___

[illegible] = [illegible] = [illegible]

Step 3b

Ave Storage = $\frac{3.88 + 3.74}{2} = 3.81$

Ave Surcharge = $\frac{3.81 \times 1.45}{2.N/A} = 370$ Acre-ft

From Stage-Discharge Curve at El. = 828.28

From Stage-Discharge Curve for Q = [illegible]

PMF overtops dam by 828.28 - 827.33 = 0.95 ft

$Q_{P2} = 4350$ cfs

Try ½ PMF = 2485 cfs

Step 1: $Q_{P1} = 0$ cfs

Step 2a: Surcharge Height = 827.38

Step 2b: Surcharge Volume = 522 Acre-ft

Inches of Runoff = $\frac{522 \text{ Acre-ft}}{1795 \text{ Acres}} \times 12 = 3.49$ in

Step 2c: $Q_{P2} = 0 + 2485 \left(1 - \frac{3.49}{9.5}\right) =$

$Q_{P2} = 1572$ cfs

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

CHKD. BY ______ DATE ______ [illegible] PROJECT [illegible]

SUBJECT [illegible] DAM [illegible]

STEP 1 & 3 FOR Q = 1,872 CFS

SURCHARGE [illegible] = 827.75

SURCHARGE VOLUME = 495 AC-FT

INCHES OF RUNOFF = $\frac{495}{[illegible]}$ × 12 in/ft = [illegible] IN.

STEP 2 AVE STORAGE $\frac{[illegible]}{2}$ = 3.4 [illegible]

AVE SURCHARGE = $\frac{3.4 \times [illegible]}{12\ in/ft}$ = 300 AC-FT

FROM STAGE STORAGE CURVE [illegible] = 827.65

FROM STAGE DISCHARGE CURVE Q_{P3} = 2,100 CFS

½ PMF [illegible] OVERTOPS DAM AND DIKE BY 827.90 − 827.35 = 0.50'
Q_{P3} = 2,100 CFS

BY ____ DATE ____ LOUIS BERGER & ASSOCIATES INC. SHEET NO ____ OF ____

CHKD. BY ____ DATE ____ PROJECT ____

SUBJECT ____

Step 2a Reservoir Elev. = Full = 327.35

Water at Top of Dam

Storage = 2737 Acre-ft

Height above Bottom at Top of Dam

= 327.35 - 296.3 ≈ 31 ft

Assume failure height to bottom at top of dam

Storage about Elevation 296.3

$S = 2737 - \frac{1}{3}(26.7)\frac{26.7}{35}(24)$

$S = 2737 - 536 \approx 2200$ Acre-ft

Height = 300 ft

Step 2 b Peak Failure Outflow

$Q_{p_1} = 8/27\ W\sqrt{g}\ y_o^{3/2}$

W = 38% L = 38% × 500 = 190 ft

y_o = 31 ft

$Q_{p_1} = 1.68\ (190)(31)^{3/2}$

$Q_{p_1} = 55{,}094$

Add Flow due to Q_{in}

Q_{p_1} Total = 55,094 + 563 = 55,657

Say Q_p = 55,000 cfs

BY _____ DATE _____ **LOUIS BERGER & ASSOCIATES INC.** SHEET NO _____ OF _____

CHKD. BY _____ DATE _____ PROJECT _____

SUBJECT _____

Sta 0+00 to Sta 28+00

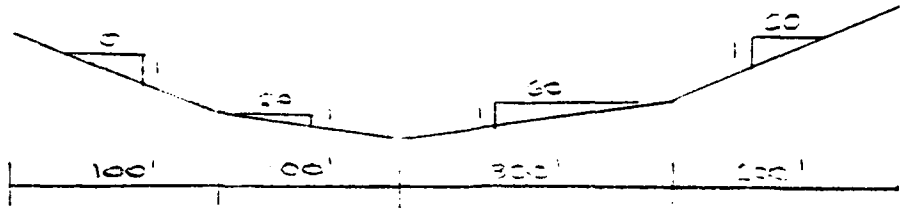
n = .03

$Q = \frac{1.49}{n} R^{2/3} S^{1/2}$

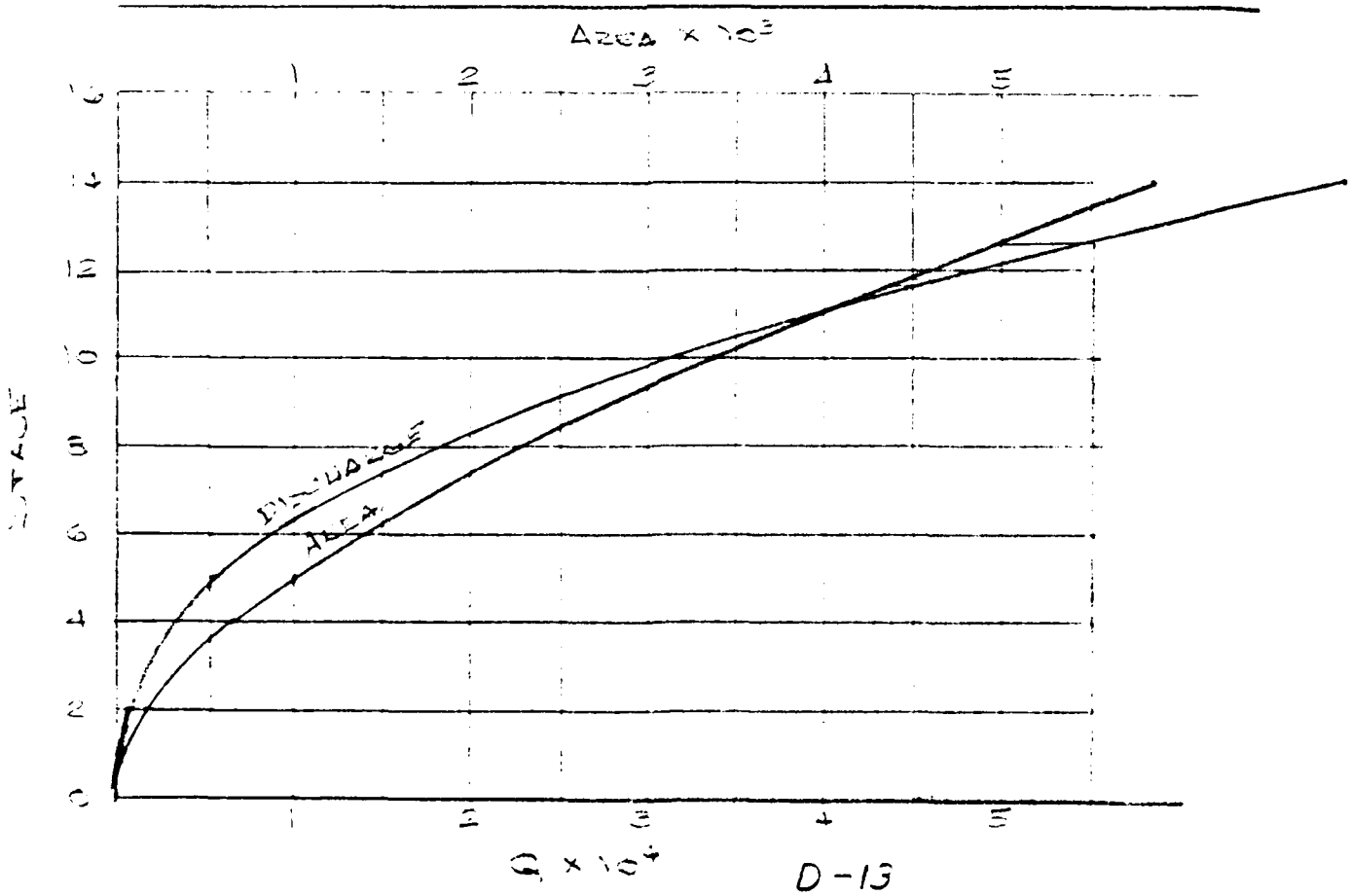
$Q = 1.52 A R^{2/3}$

$S = \frac{750 - 722}{2540} = .011$

$S^{1/2} = 0.11$



Stage	A	P	R	$R^{2/3}$	Q
2	160	160.1	1.0	1.0	151
5	1000	1000.2	1.0	1.00	1510
10	3375	550.6	6.1	3.35	31690
14	5815	970.3	8.7	4.22	64300



FOR Q = [illegible], STAGE = 13.7, A = 4500

$V_1 = \frac{4500 \times 2500}{45,560} = 250$ ACRE-FT

Q_{PC} (TRIAL) $= 55,000 \left(1 - \frac{250}{2200}\right)$

Q_{PC} (TRIAL) $= 47,000$

FOR Q = 47,000, STAGE = 11.6, A = 4500

$V_2 = \frac{4500 \times 2500}{45,560} = 259$ ACRE-FT

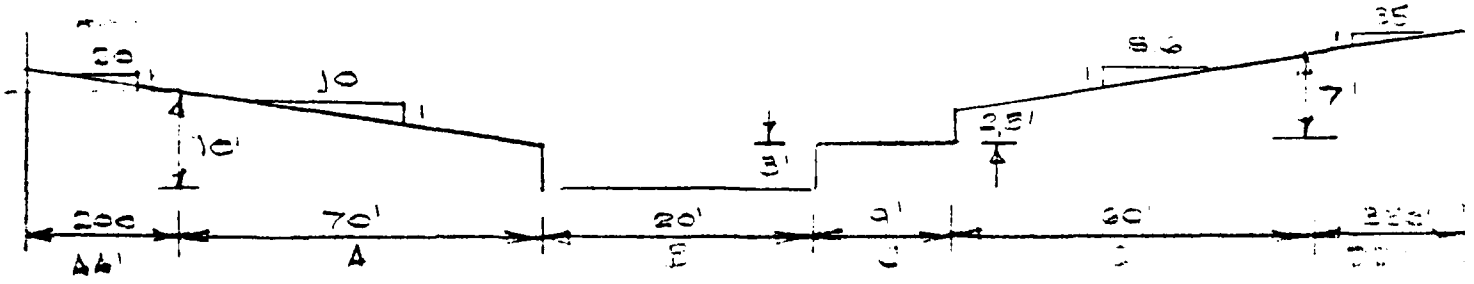
$V_{AVE} = 304$ ACRE-FT

$Q_{PC} = 55,000 \left(1 - \frac{304}{2200}\right)$

$= 47,400$

STA 28+00, Q = 47,400, STAGE = 11.9, ΔH = 9.5 FT

STA 28-00 TO STA 33+00
(OUTLET TO SMITH POND)



OUTLET STRUCTURE
SMITHS POND

BY _____ DATE _____ **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. _____ OF _____

CHKD. BY _____ DATE _____ PROJECT _____

SUBJECT _____

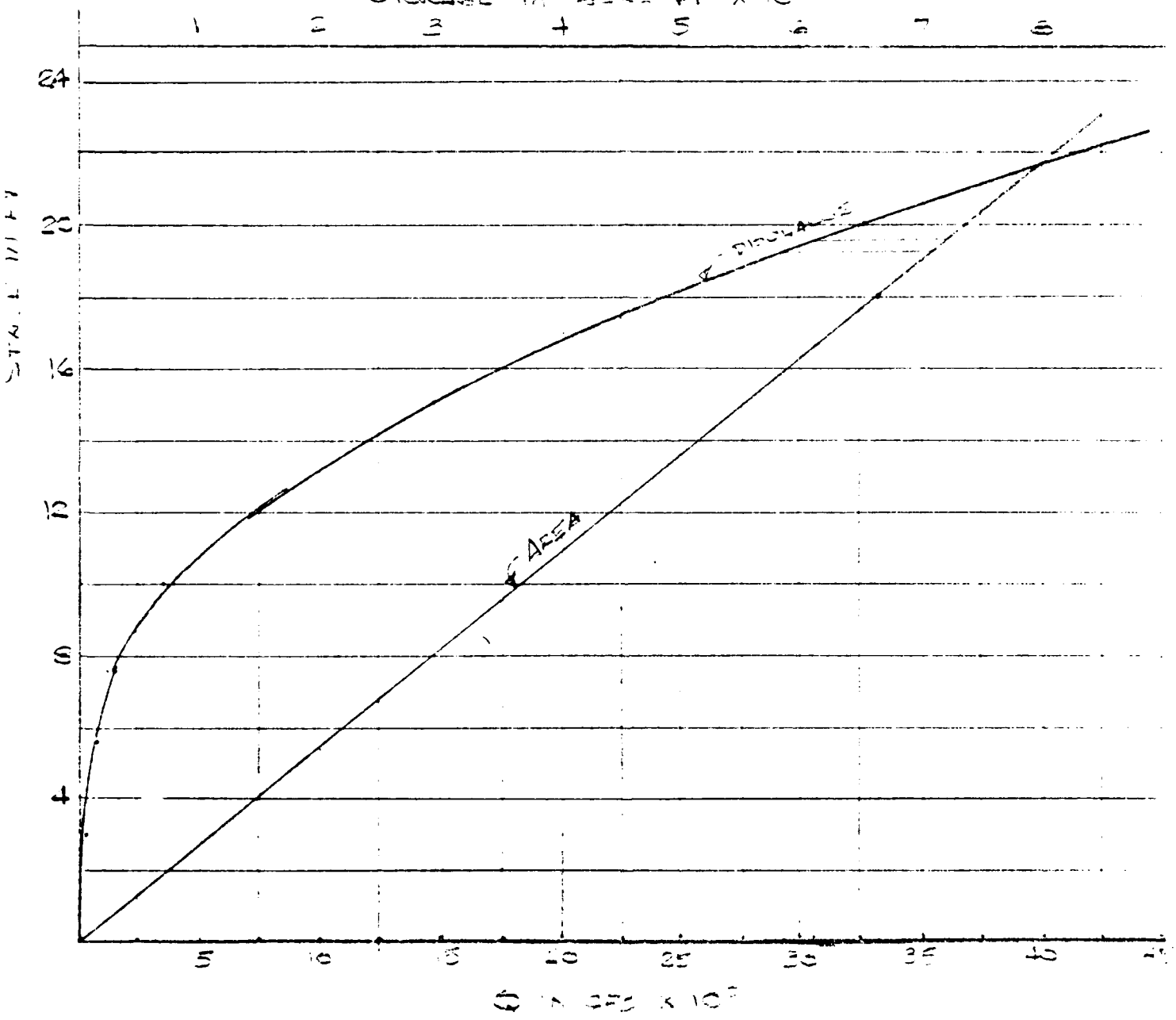
BY ____ DATE ____ LOUIS BERGER & ASSOCIATES INC. SHEET NO. ____ OF ____

CHKD. BY ____ DATE ____ PROJECT ____

SUBJECT ____

SUBSEQUENT STORAGE IN ENT. POOL

$V = (0.40)(91.92)(\quad) = 662$ ACRE-FT



REACH = E

BY SEE DATE [illegible] LOUIS BERGER & ASSOCIATES INC. SHEET NO [illegible] OF [illegible]

CHKD. BY DATE INSPECTION OF DAMS PROJECT [illegible]

SUBJECT [illegible]

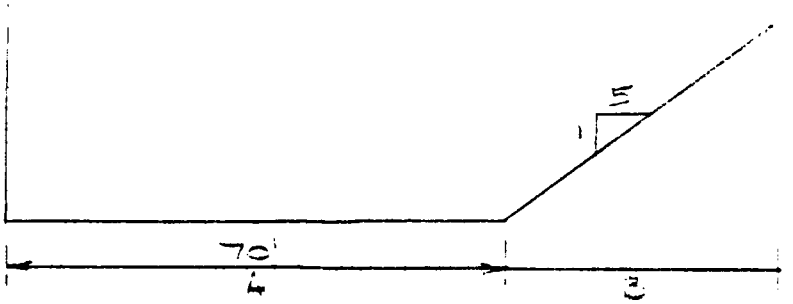
Q_{50} (...) = 47,400 (- ...) = 29,300 ...

For Q = 29,300 V_c = 703 $V_{...}$ = 776

Q_{PL} = 47,400 (- $\frac{776}{2200}$) = 30,600 cfs

Sta 30+00, Q = 30,600, H = 10.5, L = ? 15 ft

Sta 22+00 to Sta 62+00, L = 2400 ft



Dam & Spillway Wall Cross Section

Stage	A, ...			B, ...			MQ
FT	H	L	Q	H	L	Q	
3	3	70	1130	1.5	15	82	1212
6	6		3392	3	30	468	3860
9	9		6650	4.5	45	1044	7694
12	12		11311	6	60	2245	13560
15	15	7	18213	7.5	75	4220	17433
18	18		7106	3	90	7290	24396

Area of Slope AB = $\frac{18 \times 70}{2}$ = (Sec. ...) ft. = 2205 ft

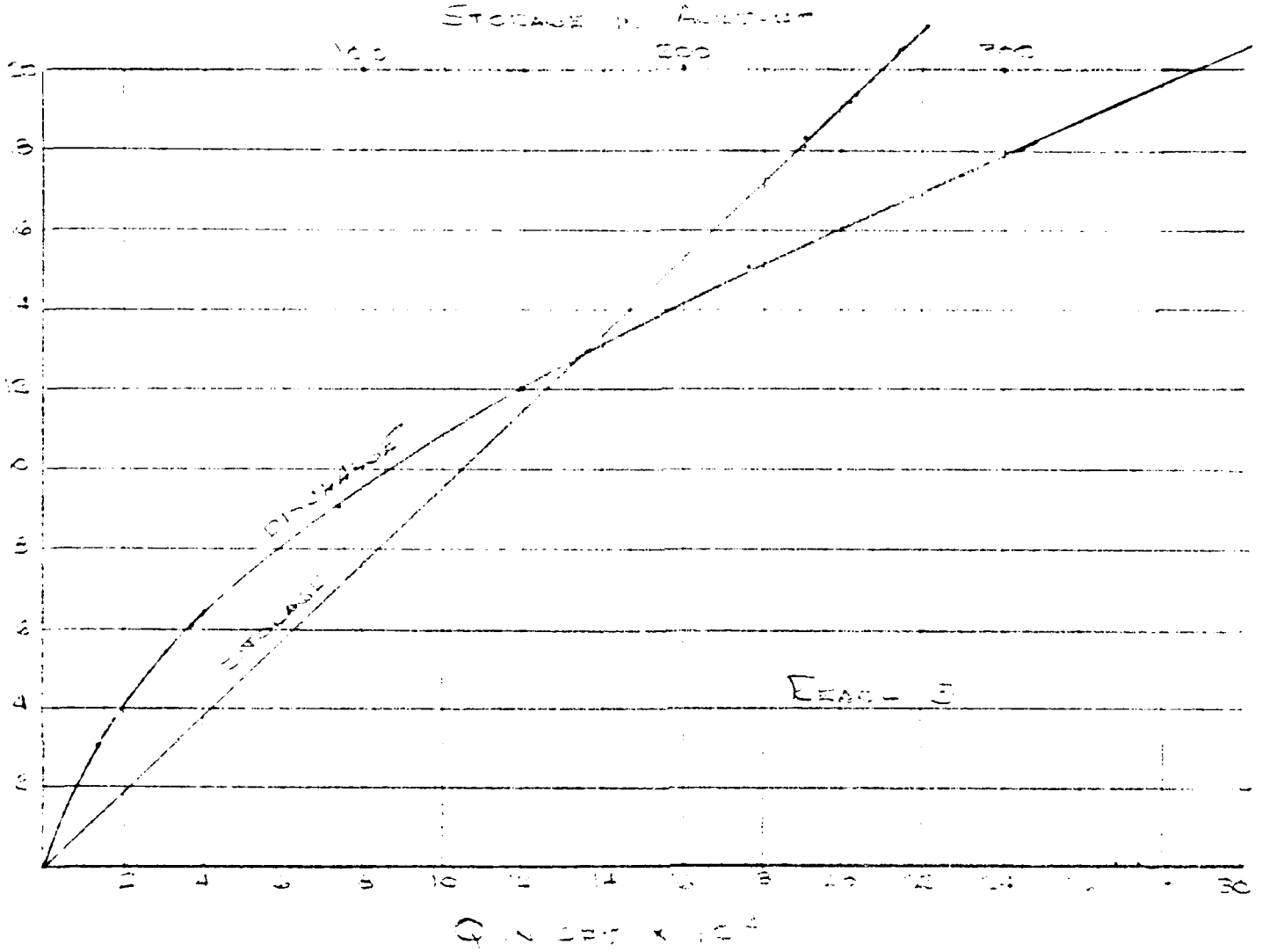
Say Cross Sectional Area is taken as ... for storage purposes

$V = \frac{4140 \times 2400}{43560} \approx$ 230 Acre-ft

BY RFH DATE [illegible] LOUIS BERGER & ASSOCIATES INC. SHEET NO. 7 OF 7

CHKD. BY ____ DATE ____ PROJECT [illegible]

SUBJECT [illegible]



$$Q_{P2}\ (T_L - L) = 30{,}600\left(1 - \frac{270}{2200}\right) = 26{,}850$$

For $Q = 26{,}850$, $V_2 = 250$ $\quad V_{AVE} = 260$

$$Q_{P2} = 30{,}600\left(1 - \frac{260}{2200}\right) = 27{,}000$$

STA 62+00, $Q = 27{,}000$, [illegible]

BY _____ DATE _____ LOUIS BERGER & ASSOCIATES INC. SHEET NO _____ OF _____

CHKD. BY _____ DATE _____ PROJECT _____

SUBJECT _____

$$Q = A\sqrt{\frac{2gh}{\Sigma K}}$$

$$Q = \frac{\pi D^2}{4}\sqrt{\frac{2g(34.7)}{7.4}} = 88.1 \text{ CFS}$$

$$Q = \pi\sqrt{\frac{2g(42.05)}{7.4}} = 60.7 \text{ CFS}$$

BY _____ DATE _____ LOUIS BERGER & ASSOCIATES INC. SHEET NO. _____ OF _____

CHKD. BY _____ DATE _____ PROJECT _____

SUBJECT _____

STEP 2: [illegible]

ASSUME [illegible]

STORAGE AREA METHOD

$\Delta Y = 2737.3300 + \frac{1}{3}(4)(h_1 + h_2 + \sqrt{h_1 h_2})$

$\Delta Y = 437 + \frac{1}{3}(96)(.02 + .24 + \sqrt{.02 \times .24})$

$\Delta Y = 437 + 1053 + 1500$

SAY 1520 AF

[illegible]

LENGTH OF DU [illegible] 1050+450 = 1500 FT

W = 20% OF 650 FT = 130 FT

STEP 2: PEAK FLOW [illegible]

$Q_{P1} = 8/27 \times A\sqrt{H_2} \times L^{1/2}$

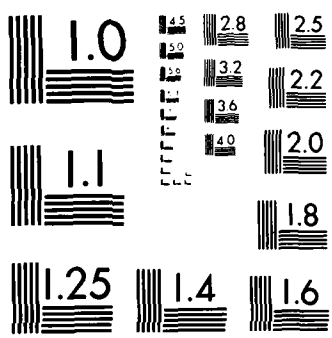
$Q_{P1} = 1.62 (130)(.4)^{1/2}$

$Q_{P1} = 1600$ CFS

NO OF CENTER DIVIDE

AD-A154 692 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS LYNDE BROOK RESERVOIR.. (U) CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV MAY 80 2/2

UNCLASSIFIED F/G 13/13 NL

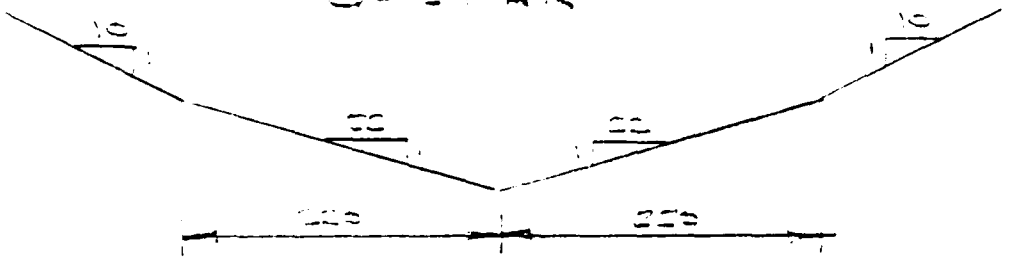


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

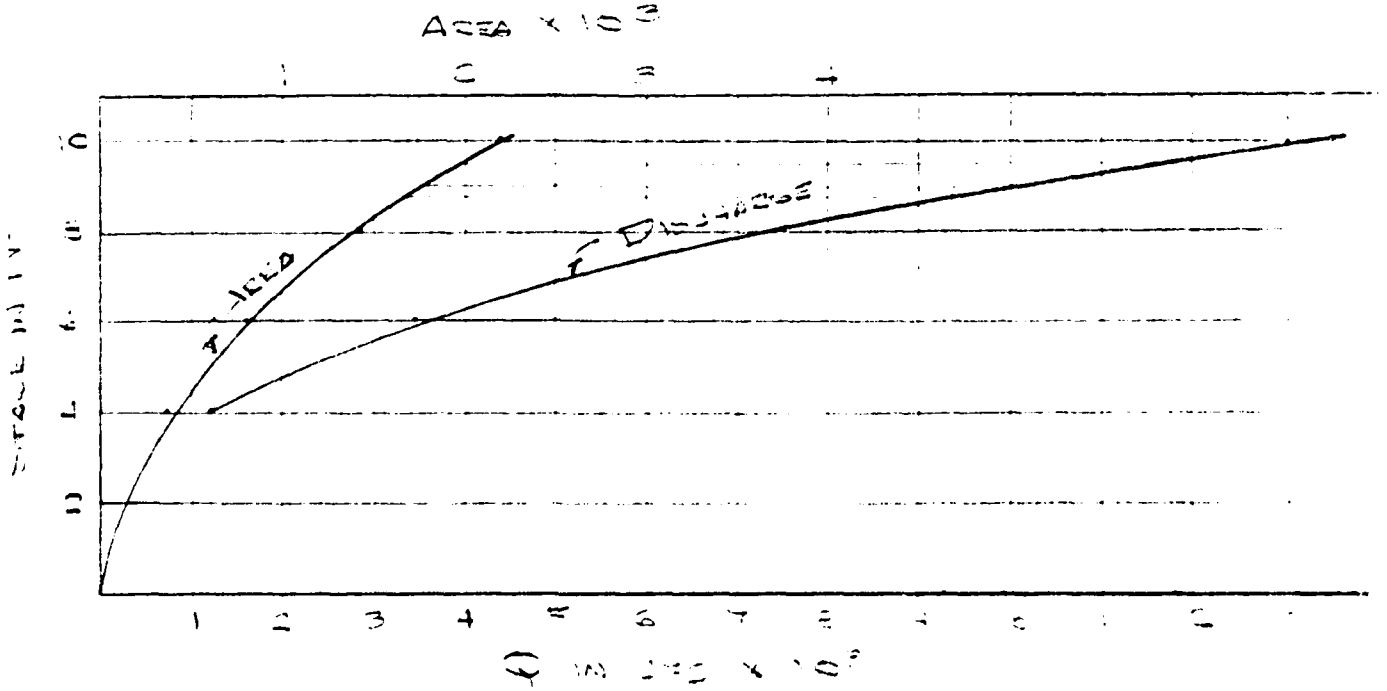
BY ____ DATE ____ **LOUIS BERGER & ASSOCIATES INC.** SHEET NO ____ OF ____

CHKD. BY ____ DATE ____ PROJECT ____

SUBJECT ____



STAGE	AREA	P	R^2/3	Q
4	352	1762	1.54	1180
6	712	2643	3.09	5478
8	1408	3524	3.53	7200
10	2200	4405	3.92	13540
12	3168	4887	4.18	22910



BY RTB DATE 7-22-76 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO 3 OF ...

CHKD. BY ..... DATE ..... PROJECT ...

SUBJECT ...

For Q = 7,800 Stage = 45 ft, Area = 2000 sf

$$V_1 = \frac{7000 \times 2000}{43,560} = 322 \text{ fps}$$

$$Q_{pc} = 11,500\left(1 - \frac{322}{500}\right)$$

" " = 4270 cfs

For 4270, Stage = 8.8 ft, Area = 1700 =

$$V_2 = \frac{7000 \times 1700}{43,560} = 273 \text{ fps}$$

$$V_{AVE} = \frac{322 - 273}{2} = 298 \text{ fps}$$

$$Q_{pc} = 11,500\left(1 - \frac{298}{500}\right) = 3,450 \text{ cfs}$$

Stage = 9 ft, + Homes Flood (Library Valley) 2 to 6 ft

Stream now goes into a closed conduit which is extended to ...

Twin Conduit 28 ft high x 5 ft ...

Area of Wing ... Conduit = ... = 7-3 + 4 = 11 sf

D/D = 5.8, Q/E = 45, E = 4 ft.

Max ... Conduit = ... cfs.

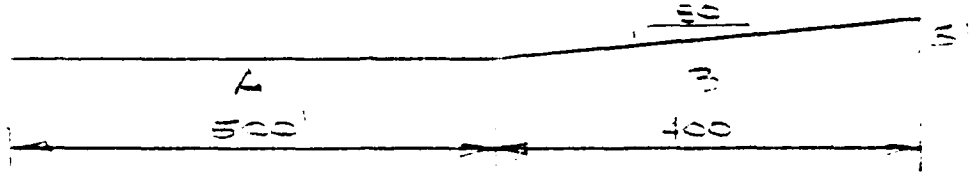
Total ... = 9,000 cfs ...

BY _____ DATE _____ **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 4 OF _____

CHKD. BY _____ DATE _____ PROJECT _____

SUBJECT _____

R-9 [illegible]

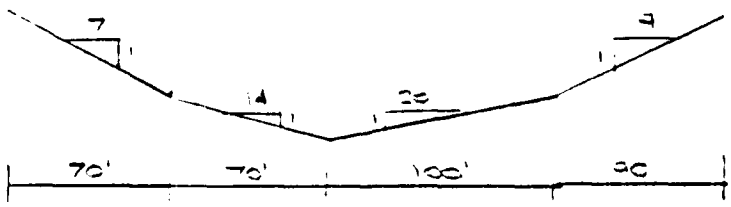


ASSUME [illegible]

			C=.26			C=.26	
STAGE	H	—	Q	H	—	Q	AF
		50'	1300	.5	80	75	1750
2	2		3680	1.0	160	420	4100
3	3	\	6750	1.5	240	1150	7900
4	4	4	10400	2	320	2350	12750

DEPTH OF FLOW ALONG R-9 [illegible]
$\Delta V \geq 50$ A.F.

SECTION IN RESIDENTIAL AREA SOUTH OF [illegible]

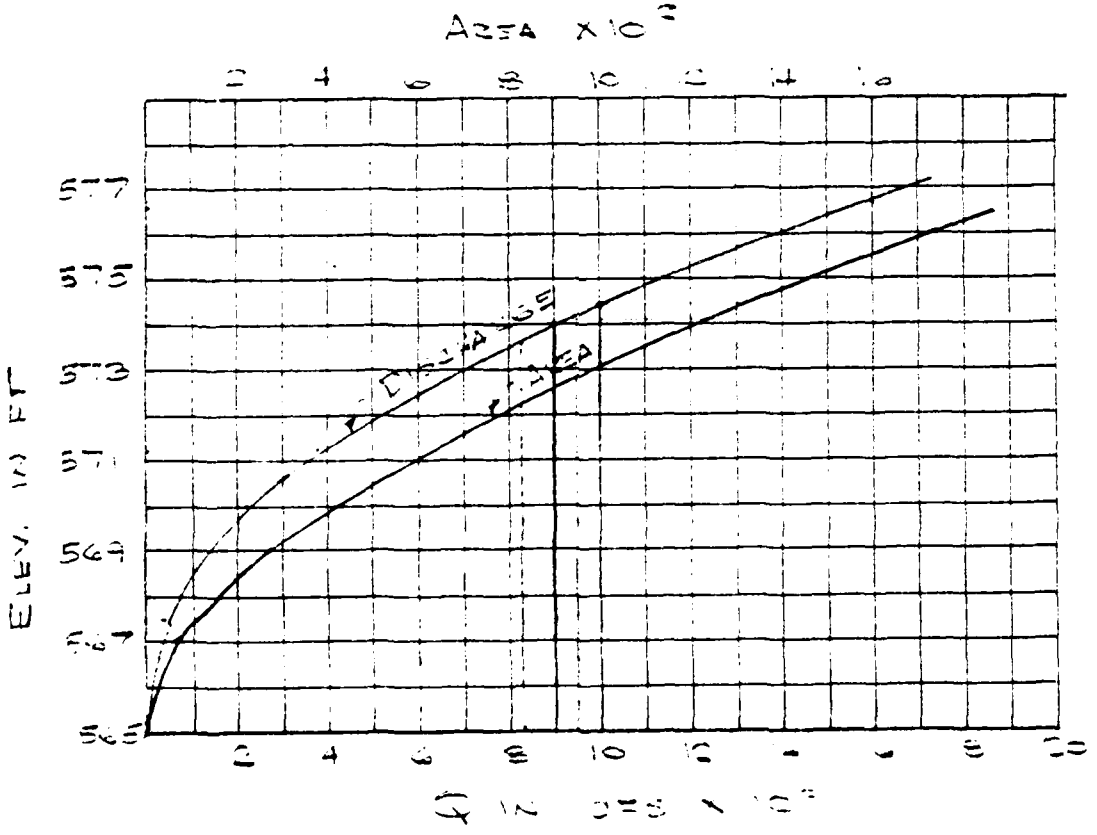


BY _____ DATE _____ **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. _____ OF _____

CHKD. BY _____ DATE _____ PROJECT _____

SUBJECT _____

ELEV	DEPTH	TOP WIDTH	AREA	Q_c	V_c	$\alpha V_c^2/2g$	$\alpha_{avg} V_{avg}^2/2g$	WS ELEV
568	0	0	—	—	—	—	—	568
569	1	68	68	356	5.24	0.43	0.35	569.3
571	3	156	272	2153	7.92	0.97	0.80	570.0
573	5	170	485	3813	7.87	0.96	0.81	571.2
575	7	200	797	6453	8.09	1.02	0.86	573.1
574	9	234	1033	6660	13.02	2.63	1.16	574.6
576	11	248	1733					



BY [illegible] DATE [illegible] **LOUIS BERGER & ASSOCIATES INC.** SHEET NO [illegible] OF [illegible]

CHKD. BY [illegible] DATE [illegible] PROJECT [illegible]

SUBJECT [illegible]

[illegible] = 9,450 [illegible]

[illegible]

$$V_1 = \frac{1500 \times 3 \times 1220}{43,560} = 126 \text{ A.F.}$$

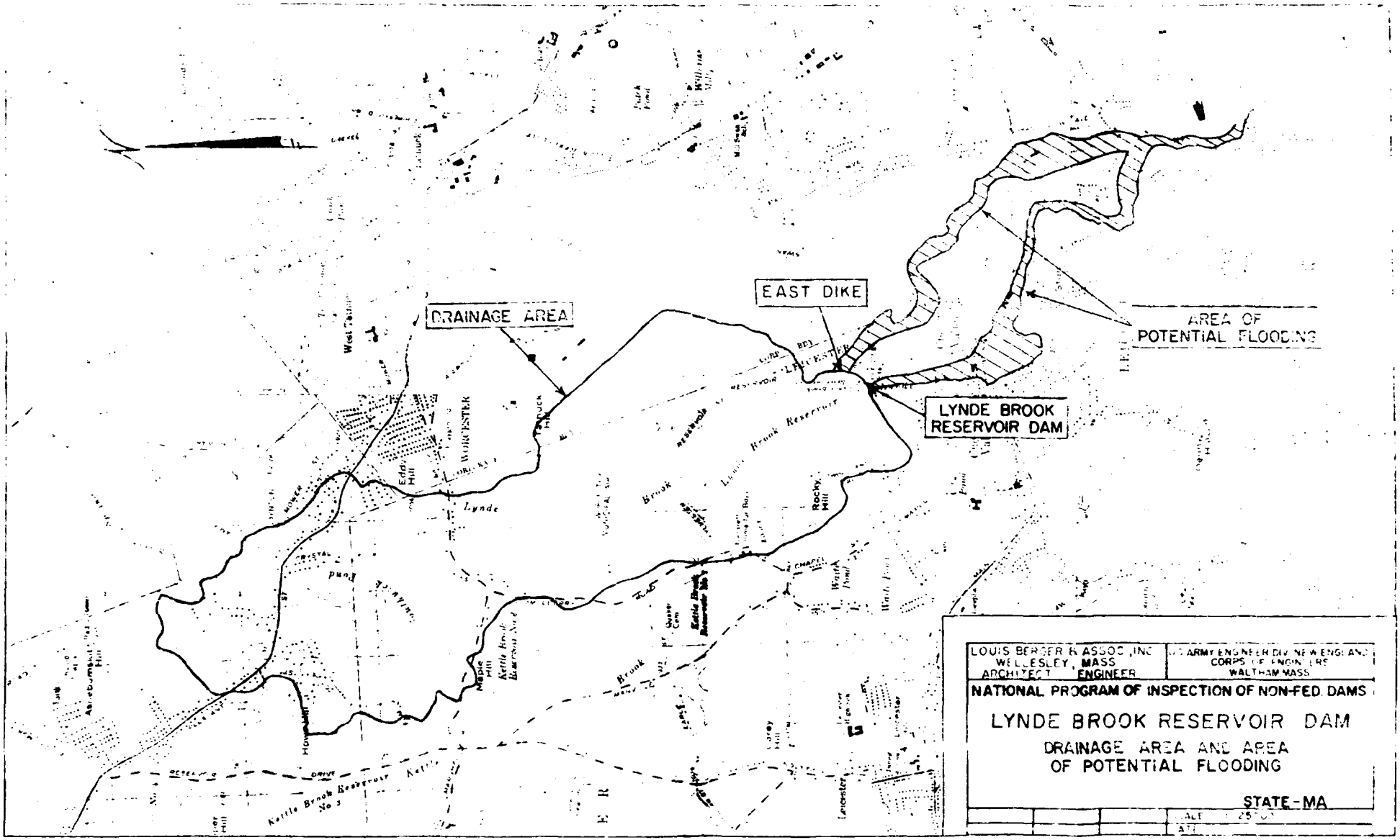
[illegible]

$$Q_{P2\,(T24)} = 9,450 \left(- \frac{126 + 50}{1500} \right)$$

[illegible] = 8340 [illegible]

[illegible]

50-70 [illegible] 1 - [illegible]
6 [illegible] 1 - [illegible]
1 [illegible] [illegible]
1 [illegible] [illegible]



D 2e

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES

(1) DIVISION	(2) STATE	(3) COUNTY	(4) CONGR DIST.	(5) STATE	(6) COUNTY	(7) CONGR DIST.	(8) NAME	(9) LATITUDE (NORTH)	(10) LONGITUDE (WEST)	(11) REPORT DATE DAY	MO	YR
		027	03				LYNDE BROOK RESERVOIR DAM	4215.1	7152.4	00	00	80

(12) POPULAR NAME	(13) NAME OF IMPOUNDMENT
	LYNDE BROOK RESERVOIR

(14) HUC SUBBASIN	(15) RIVER OR STREAM	(16) NEAREST DOWNSTREAM CITY-TOWN-VILLAGE	(17) DIST FROM DAM (MI.)	(18) POPULATION
11 09	LYNDE BROOK	LEICESTER	0	9100

(19) TYPE OF DAM	(20) YEAR COMPLETED	(21) PURPOSES	(22) STRUCTURAL HEIGHT (FT.)	(23) HYDRAULIC HEIGHT (FT.)	(24) IMPOUNDING CAPACITIES MAXIMUM (ACRE-FT.)	NORMAL (ACRE-FT.)	(25) DIST	OWN	FED R	PRV/FED	SCS A	VER/DATE
PG	1876	S	59	59	2737	2300	NED	N	N	N	N	16APR80

(26) REMARKS

(27) U S	(28) SPILLWAY CAP. (CFS)	(29) TYPE	(30) WIDTH (FT.)	(31) MAXIMUM DISCHARGE (CFS)	(32) VOLUME OF DAM (CY)	(33) POWER CAPACITY INSTALLED (MW)	PROPOSED (MW)	(34) NAVIGATION LOCKS NO.	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)
	530	U	29	560	76500											

(35) OWNER	(36) ENGINEERING BY	(37) CONSTRUCTION BY
CITY OF WORCESTER, MA	AM. J. MCALPINE	

(38) REGULATORY AGENCY DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NE	NONE	NONE	NONE

(39) INSPECTION BY	(40) INSPECTION DATE DAY MO YR	(41) AUTHORITY FOR INSPECTION
LOUIS BERGER & ASSOC INC	16APR80	PL92-367

(42) REMARKS

INVENTORY OF DAMS IN THE UNITED STATES

STATE	NATIONAL ID NUMBER	DIVISION	STATE	COUNTY	CONGR DIST.	STATE	COUNTY	CONGR DIST.	NAME	LATITUDE (NORTH)	LONGITUDE (WEST)	REPORT DATE DAY | MO | YR
	[illegible]	NED	MA	027	05				LYNDE BROOK RESERVOIR DIKE	4215.1	7152.4	16APR80

POPULAR NAME	NAME OF IMPOUNDMENT
	LYNDE BROOK RESERVOIR

REGION	BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY–TOWN–VILLAGE	DIST FROM DAM (MI.)	POPULATION
01	09	TR-KETTLE BROOK	LEICESTER	0	9100

TYPE OF DAM	YEAR COMPLETED	PURPOSES	STRUCTURAL HEIGHT (FT.)	HYDRAULIC HEIGHT (FT.)	IMPOUNDING CAPACITIES MAXIMUM (ACRE-FT.)	IMPOUNDING CAPACITIES NORMAL (ACRE-FT.)	DIST	OWN	FED R	PRV/FED	SCS A	VER/DATE
ERG	1976	S	14	14	1520	1080	NED	N	N	N	N	16APR80

REMARKS

DAMS HAS	SPILLWAY CREST LENGTH	SPILLWAY TYPE	SPILLWAY WIDTH (FT.)	MAXIMUM DISCHARGE (FT.)	VOLUME OF DAM (CY)	POWER CAPACITY INSTALLED (MW)	POWER CAPACITY PROPOSED (MW)	NAVIGATION LOCKS NO.	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)
1	1050	N			18000											

OWNER	ENGINEERING BY	CONSTRUCTION BY
CITY OF WORCESTER, MA		

REGULATORY AGENCY			
DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
E	NONE	NONE	NONE

INSPECTION BY	INSPECTION DATE DAY | MO | YR	AUTHORITY FOR INSPECTION
LOUIS BERGER & ASSOC INC	16APR80	PL92-367

REMARKS

SPILLWAY AT DAM MA00990

END

FILMED

7-85

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