

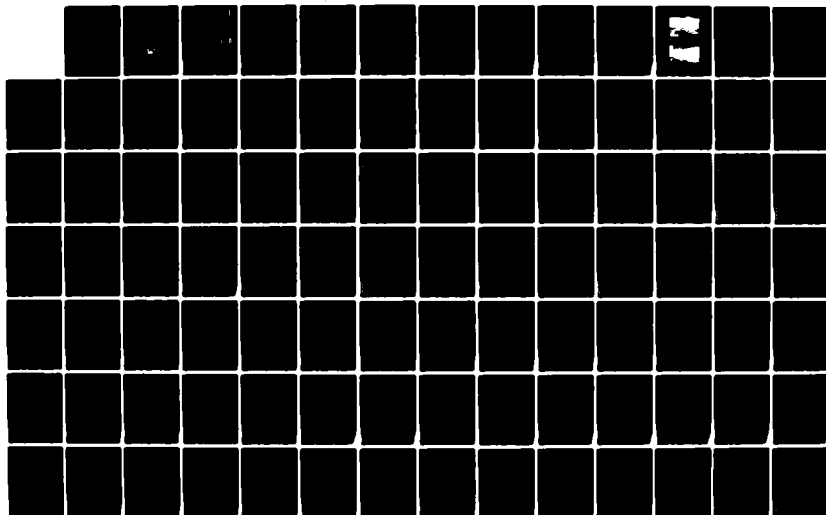
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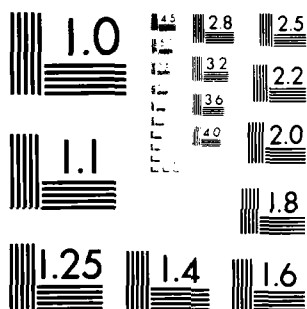
NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
LAKE GARDNER DAM (MA...) (U) CORPS OF ENGINEERS WALTHAM MA
NEW ENGLAND DIV SEP 78

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MERRIMACK RIVER BASIN
AMESBURY, MASSACHUSETTS

LAKE GARDNER DAM

MA 00152

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



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

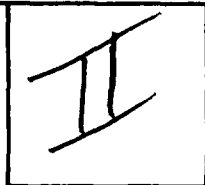
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INVENTORY

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Sep. '78

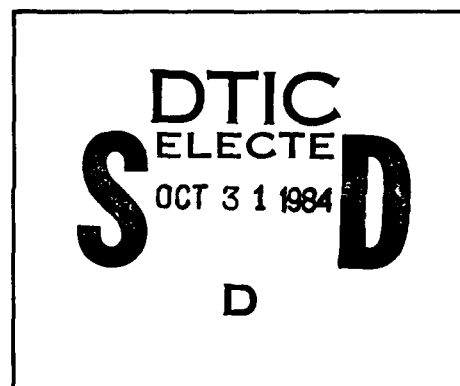
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) DAMS, INSPECTION, DAM SAFETY, Merrimack River Basin Amesbury, Mass.		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Lake Gardner Dam is located approximately 2000 ft. upstream of the center of Town. The dam consists of an earth embankment approximately 750 ft. long and 25 ft. high. The earth embankment is in fair to poor condition. The dam is classified as having a "high" hazard potential. Hydraulic analyses indicated that the spillway is not capable of passing the test flood.		

LAKE GARDNER DAM
MA 00152

MERRIMACK RIVER BASIN
AMESBURY, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

PHASE I INVESTIGATION REPORT
NATIONAL DAM INSPECTION PROGRAM

BRIEF ASSESSMENT

Identification No.:	MA 00152
Name of Dam:	Lake Gardner
Town:	Amesbury
County:	Essex
State:	Massachusetts
Stream:	Powwow River
Date of Site Visit:	18 July 1978

The Lake Gardner Dam is located approximately 2000 ft. upstream of the center of the Town of Amesbury. The dam consists of an earth embankment approximately 750 ft. long and 25 ft. high and an ungrated granite block spillway about 73 ft. wide and 16 ft. high. A 24-in. reservoir drain is the only existing outlet.

The dam is believed to have been originally constructed in 1872. In 1929, the embankment and spillway training walls were raised approximately 3.5 ft. to provide additional protection against overtopping. While the dam was initially constructed to provide water power for mill machinery it was modified to generate electricity some time after 1916. Later, the power equipment was removed and the penstock concreted. Presently, the dam retains Lake Gardner which is used for recreational purposes only.

Lake Gardner Dam is currently classified as having a "high" hazard potential in the Corps of Engineers National Inventory of Dams.

Based on a visual examination, the earth embankment is in fair to poor condition, primarily because of severe erosion on the upstream slope due to wave action. The spillway and training walls are in poor condition. While there were no obvious signs of failure or conditions which would warrant urgent remedial treatment, repairs to the embankment should be accomplished by the owner within one to two years after receipt of this report to prevent further erosion and possible overtopping during a major storm.

Until permanent reconstruction of the earth embankment is accomplished, the Town of Amesbury should prepare to undertake al-

ternative measures for assuring temporarily that the dam will not be overtopped. These measures are outlined in Section 7.3 and should be undertaken immediately.

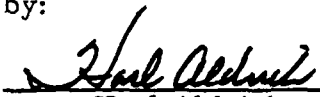
Hydraulic analyses indicated that the spillway is not capable of passing the test flood, which for this structure is based on the probable maximum flood, without overtopping the dam. The maximum capacity of the spillway, with the pool level at the top of dam, is only 49 percent of the test flood.

Recommendations for additional investigations of embankment and spillway structural stability under static and seismic loads are in Section 7.2. The structure is located in Seismic Zone 3.

Finally, remedial work to be implemented by the owner involves additional clearing of trees at the toe of the embankment, re-pointing of stone masonry on the spillway and training walls and earthwork and slope protection left (east) of the spillway as described in Section 7.3.

HALEY & ALDRICH, INC.

by:


Harl Aldrich
President



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 investigations are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the test flood is based on the estimated "probable maximum flood" for the region (greatest reasonably possible storm runoff), or a fraction 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.

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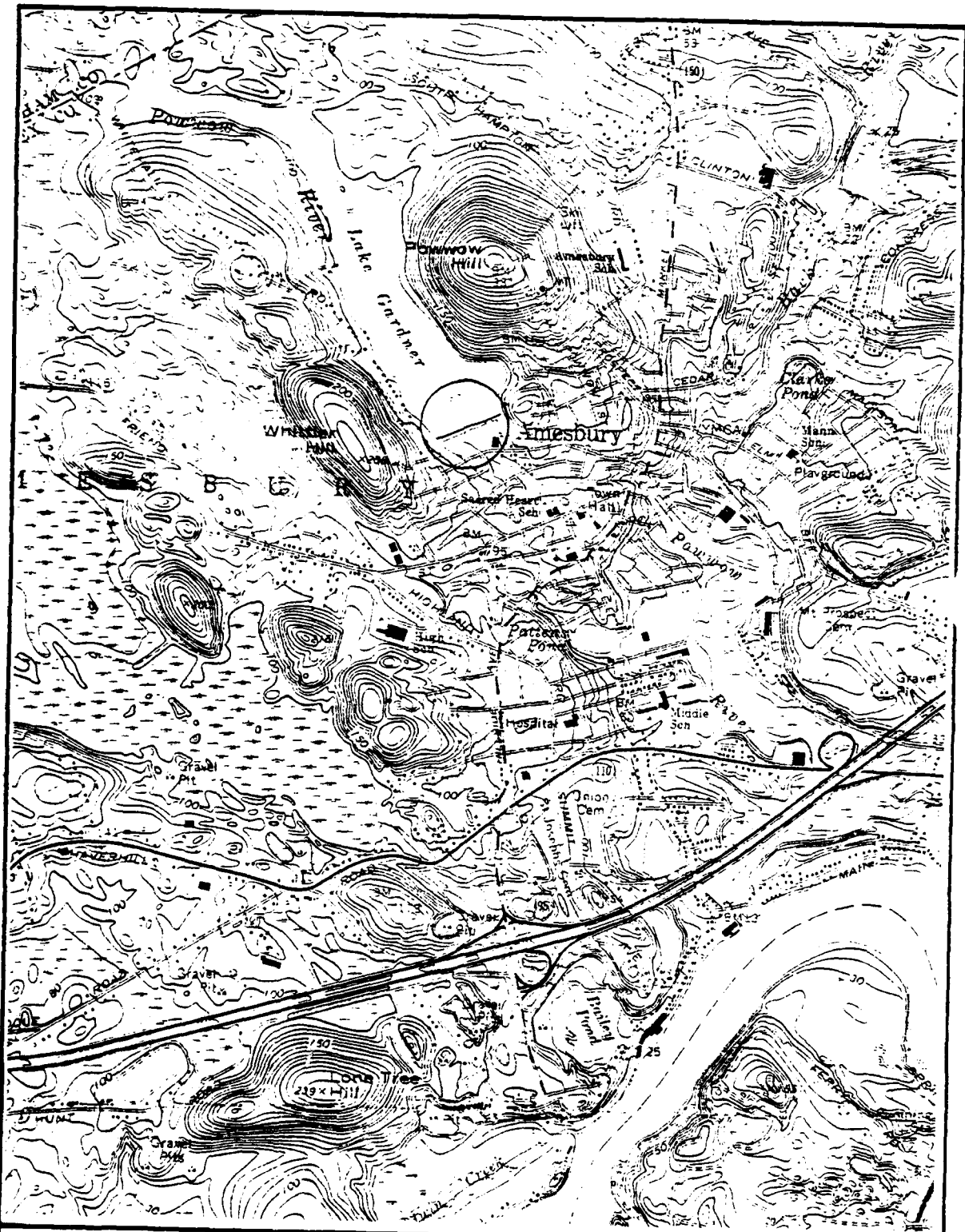
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1. Overview of dam showing downstream slope

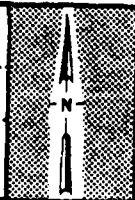


2. Overview of dam showing upstream slope



FILE NO. 4160

DAM: Lake Gardner
 IDENTIFICATION NO. MA 00152



LOCATION MAP
 USGS QUADRANGLE
 NEWBURYPORT WEST (MASS)
 APPROX. SCALE: 1" = 2000'

PHASE I INVESTIGATION REPORT
NATIONAL DAM INSPECTION PROGRAM
LAKE GARDNER DAM
MA 00132

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.

Haley & Aldrich, 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 were issued to Haley & Aldrich, Inc. under a letter dated 26 April 1978 from Colonel Ralph T. Garver, Corps of Engineers. Contract No. DACW33-78-C-0301 has been assigned by the Corps of Engineers for this work. Camp, Dresser & McKee, Inc. was retained as consultant to Haley & Aldrich, Inc. on the structural, mechanical/electrical and hydraulic/hydrologic aspects of the investigation

B. Purpose. The primary purposes of the National Dam Inspection Program are to:

1. Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.
2. Encourage and prepare the states to initiate quickly effective dam safety programs for non-Federal dams.
3. To update, verify and complete the National Inventory of Dams.

1.2 PROJECT DESCRIPTION

A. Location. Lake Gardner Dam is located on the Powwow River about 2000 ft. upstream of the Town of Amesbury, Massachusetts, as shown on the Location Map, page viii.

B. Dam and Appurtenances. Lake Gardner Dam is approximately 1000 ft. long, consisting mainly of an ungated granite block spillway, a long earth embankment to the right and a short, low earth embankment to the left. An abandoned penstock and generator house, once used to power mill equipment, is located at the left abutment of the spillway. Drawings of the dam are shown on Figures B-1 and C-1.

The earth embankment right of the spillway is approximately 750 ft. long and has a maximum height of about 25 ft. The top of the embankment is earth, approximately 9 to 10 ft. wide. The upstream face has a variable slope of from 2 horizontal to 1 vertical to 1:1 where erosion has occurred. There is no riprap. The downstream slope is about 1.5:1 near the top and somewhat flatter toward the bottom.

Left of the spillway, there is a low embankment which is typically from 1 to 3 ft. in height and about 175 ft. in length.

The embankment has a line of tongue and groove wood sheeting as a center core wall, the top of which is El. 97.0, 1.5 ft. below the top of earth fill. A concrete core wall, or vertical seepage barrier, was constructed to a point 12 ft. from the spillway-side face of new concrete placed on the spillway training walls in 1929. Wood sheeting abuts the end of the concrete wall.

The spillway is a broad crested granite masonry structure, about 16 ft. high and 72.6 ft. wide. The nine courses of stone exposed on the downstream face of the weir are stepped. Training walls are stone masonry. The crest of the spillway is El. 90.37, 8.13 ft. below the top of the dam.

The outlet works is located left of the spillway. The reservoir drain is a 24-in. pipe with a hand-operated gate valve at the discharge end. A 6-ft. diameter penstock, once used to power mill machinery and generate electricity, has been blocked with concrete and is no longer functional.

C. Size Classification. The Lake Gardner Dam has an estimated maximum storage of 1208 acre-feet and a maximum height of about 25 ft. Storage of from 1,000 to 30,000 acre-feet classifies the dam in the "intermediate" size category, even though the height is small, according to guidelines established by the Corps of Engineers.

D. Hazard Classification. The dam is currently classified as having a "high" hazard potential in the Corps of Engineers National Inventory of Dams. Based on the Phase I investigation, and the dam failure analysis, Appendix D, it is recommended that this classification be retained. If the dam were to fail, there would be severe flooding of the downtown portion of Amesbury which would affect in excess of 25 residential and commercial properties as well as some industries. The potential for loss of life would be very high.

E. Ownership. The Merrimack Valley Power and Buildings Company purchased the dam from the Hamilton Woolen Company, the original owner, in 1916. An inspection report by the Essex County Engineer indicates that on 3 December 1957, the Merrimack-Essex Electric Light Company was the owner of the dam. Another report dated 10 February 1964 shows the owner as then being the Amesbury Electric Light Company.

The dam has been owned by the Town of Amesbury since after 1964. The owner's address is: Town of Amesbury, Public Works Department, Friend Street, Amesbury, MA 01913 (phone: 617/388-0477). The owner was represented by Mr. John J. Ward, Superintendent, during the course of this investigation.

F. Operator. Mr. John Ward is currently assigned responsibility for the operation of the dam.

G. Purpose of Dam. Lake Gardner is presently used for recreational purposes only. The dam was originally constructed to form a storage reservoir to power mill machinery. Around 1916, a turbine was installed to generate electric power. The penstock was subsequently filled with concrete prior to 1952.

H. Design and Construction History. The dam is believed to have been constructed in 1872 for the Hamilton Woolen Company. No records of the original design and construction are available. In 1916, the Merrimack Valley Power and Building Company purchased the dam and modified the gate for power generating equipment. Correspondence on file at the Essex County Engineers Office indicates embankment and spillway maintenance construction activity in 1926.

In 1929, the dam embankment crest was raised approximately 3.5 ft. and underwent repairs. Concrete cut-off walls 10 ft. in length were poured on both sides of the spillway from the training walls to lap new creosoted wood sheeting installed the length of the embankments. The top of the concrete core wall on the left side can be seen in Photo No. 13, Appendix C. A list of available documents that includes design studies, contract documents and construction inspection reports for the 1929 modifications and repairs is included in Appendix B.

An inspection report dated 18 October 1951 indicates that the penstock had been plugged with concrete. No additional records of construction other than that considered to be routine maintenance were located.

I. Normal Operational Procedures. There is no established routine for operation of the dam. The manual gate for the 24-in. reservoir drain is operational.

1.3 PERTINENT DATA

Elevations shown on record drawings and previous inspection reports for the Lake Gardner Dam are on Mean Low Water (MLW) datum. To convert to National Geodetic Vertical Datum (NGVD), subtract approximately 3.8 ft. from elevations which are on MLW datum.

A. Drainage Area. The Lake Gardner Dam is located on the Powwow River in the Town of Amesbury. The watershed above the dam is 50.25 square miles and extends into the communities of the Merrimac, Massachusetts and South Hampton, Kensington, East Kingston, Newton, Kingston, Hampstead, Danville, and Sandown, New Hampshire. The drainage area is very flat with approximately 12 percent of the total area being surface water and an additional 16 percent being swamps.

B. Discharge at Damsite. There are no known records of past floods at the Lake Gardner Dam. The maximum capacity of the spillway at the dam has been estimated to be about 6,660 cfs with the water surface at the top of the dam, El. 98.5. A preliminary Flood Insurance Study currently being prepared by the Corps of Engineers has estimated the 100-year Lake Gardner discharge to be 1,800 cfs and the 500-year discharge to be 3,500 cfs.

C. Elevation (ft. above MLW)

1. Top Dam.....	98.5
2. Maximum pool design surcharge (PMF).....	100.0
3. Full flood control pool.....	98.5
4. Recreation pool.....	90.4
5. Spillway crest.....	90.37
6. Upstream portal invert diversion tunnel.....	Unknown
7. Streambed at centerline of dam.....	72.3
8. Maximum tailwater.....	79.0 (at 3,500 cfs)

D. Reservoir

1. Length of maximum pool.....	8,600 ft. (Est.)
2. Length of recreation pool.....	6,600 ft. (Est.)
3. Length of flood control pool.....	8,000 ft. (Est.)

E. Storage (acre-feet)

1. Recreation pool.....	1,155 (Est.)
2. Flood control pool.....	1,208 (Est.)
3. Design surcharge.....	1,490 (Est.)
4. Top of dam.....	1,208 (Est.)

F. Reservoir Surface (acres)

1. Top dam.....	183 (Est.)
2. Maximum pool.....	194 (Est.)
3. Flood-control pool.....	183 (Est.)
4. Recreation pool.....	97.3 (Est.)
5. Spillway crest.....	97.3 (Est.)

G. Dam

1. Type.....	Earth
2. Length (Right Side).....	Approx. 750 ft. right of spillway
3. Height (Right Side).....	Approx. 25 ft.
4. Top width.....	9-10 ft.
5. Side slopes.....	Approx. 1:1 to 2.0:1 U/S Approx. 1.5:1 to 2.0:1 D/S

- | | |
|-------------------------|---------------|
| 6. Zoning..... | Unknown |
| 7. Impervious Core..... | Wood sheeting |
| 8. Cutoff..... | Wood sheeting |
| 9. Grout curtain..... | Unknown |

H. Spillway

- | | |
|-------------------------|--|
| 1. Type..... | Broad crested,
granite block
masonry |
| 2. Length of weir..... | 72.6 ft. |
| 3. Crest elevation..... | 90.37 |
| 4. Gates..... | None |
| 5. U/S Channel..... | 10:1 approach
slope |
| 6. D/S Channel..... | 0.001 slope |
| 7. General..... | Series of steps
form downstream
face |

I. Regulating Outlets. There is one hand-operated gate valve on the left side of the downstream channel. The gate controls a 24-in. pipe having an estimated discharge invert at El. 71.8. This outlet could be used to dewater the reservoir although the time involved would be in excess of one week.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN RECORDS

No records of the design of the original dam constructed in 1872 were located or are believed to exist. The only available records are those related to the 1929 modifications.

A 1929 letter report by Sanborn and Bogert, New York, NY, describing studies and recommendations for modifications and repairs to the dam is included as a document in Appendix B. These recommendations were subsequently incorporated into a design drawing entitled "Repairs to Gardner Lake Dam, Plans & Sections" by Charles T. Main, Inc., Boston, MA dated April 2, 1929. A print of this drawing is included in Appendix B-9. The repairs shown include raising the embankment approximately 3.5 ft. and constructing a line of wood sheet-piling at the centerline of the embankment, as described in Section 1.2H.

2.2 CONSTRUCTION RECORDS

The most detailed construction records were those related to the 1929 repairs and modifications. The records consist of plans and specifications by Charles T. Main, Inc. and inspection reports by the Essex County Engineer.

An account of the 1929 construction by Robert R. Evans is included in Appendix B, from B-13 to B-24. These inspection records indicate that a cut off wall of tongue and groove creosoted yellow pine planking was in fact constructed when the embankment was raised. Furthermore, the account states that riprap was placed on the upstream slope and that the downstream slope was loamed and (in late 1929) was "--now well grassed over". Furthermore, the 1925 Report to the County Commissions states that "repairs at the spillway were made, consisting of pointing some of the walls and re-arranging the riprap at the base of the masonry spillway to protect foundations from possible scour."

Mention of some later construction activities was found in the summary inspection reports included in Appendix B. These brief statements lack detail, but acknowledge encasement of the penstock in concrete prior to 18 October 1951, replacement of wooden gate with a creosoted timber gate at the penstock prior to 3 December 1957, and routine maintenance of the embankments and spillway.

2.3 OPERATION RECORDS

A list of daily water levels at the dam from 1918 through 1927 was the only record of operation located.

2.4 EVALUATION

A. Availability. Documents described above and listed in Appendix B are available at the offices of the Essex County Engineer, 32 Federal Street, Salem, MA 01970 (phone: 617-744-1240).

B. Validity. Based on visual field observations, there is no reason to question the validity of the design, and construction and operation records.

C. Adequacy. The available data, in combination with the visual examination described in the following section are adequate for the purposes of the Phase I Investigation.

SECTION 3 - VISUAL EXAMINATION

3.1 FINDINGS

A. General. The Phase I visual examination of the Lake Gardner Dam was conducted on 18 July 1978. The project was also examined by representatives of the Corps of Engineers and their consultant, Haley & Aldrich, Inc. on 23 and 24 May 1978. Two separate reports of that site visit are included in Appendix B from B-47 through B-52.

In general, the dam embankment was found to be in fair to good condition and the spillway in fair condition. Numerous deficiencies which require prompt action were noted.

A visual inspection check list is included in Appendix A and selected photographs of the project are given in Appendix C.

B. Dam. The earth embankment, approximately 750 ft. long right of the spillway, has experienced considerable erosion on the upstream slope and has numerous defects. While there was no evidence of settlement or lateral movement, seepage is occurring in one area near the bottom of slope at the downstream toe.

The following deficiencies were noted:

1. There is considerable erosion on the upstream slope. Erosion by wave action is severe in localized areas, Photos No. 3, 4 and 5, principally where there are no cobbles and boulders at the water line. Near Sta. 4+50, the toe of slope has been eroded some 7 to 8 ft. toward the embankment centerline, Photo No. 5. The slope has no rock riprap and is void of cobbles and boulders except at the water line, about El. 90.5.

Erosion has occurred at the top of the dam and on the upstream slope from foot traffic and rainfall. Where the embankment abuts the right end of the spillway, the crest of the embankment is 7 in. below the top of concrete, El. 98.5, placed in 1929. Elsewhere right of the spillway, the crest elevation is relatively level, at an elevation corresponding to top of concrete.

2. The crest of the embankment immediately left of the spillway and outlet works, is approximately 18 in. below El. 98.5,

the top of a 10 ft. concrete wall constructed in 1929. The top of the concrete "cutoff wall" is exposed over a distance of about 5 ft. where earth has been eroded. This general condition is shown in Photo No. 13. If the dam were to overtop during a storm, water would cross the crest at this location first.

3. While most of the large hardwood trees which grew on the embankment have been cut during the past year, there are still trees covering the bottom of the downstream slope. Furthermore, stumps from one to three ft. in height can be seen in numerous photographs in Appendix C.
4. An area of seepage was observed on the downstream slope near Sta. 3+50. The top of the wet area occurs 14 ft. vertically below the crest of the dam, well above the toe of the embankment. The soft wet area is approximately 100 ft. long. There was no evidence of erosion and the water was clear.

From about Sta. 0+00 to 2+00, the area immediately downstream of the toe, in an area which is still wooded, has water ponded.

5. The crest of the embankment and both the upstream and downstream slopes are frequently bare of vegetation and have no significant topsoil.
6. Several animal holes, probably woodchuck, were noted on the downstream slope near Sta. 3+75. There was no seepage from these holes nor visible water in the holes.
7. A portion of the downstream toe of the embankment adjacent to the right training wall has been eroded by the spillway tailwater.

Left of the spillway, beyond the area where erosion has occurred as noted in Item No. 2 above, the earth embankment is typically one to three ft. in height, adjacent to a paved parking area as shown in Photo No. 1. There are several large trees on the upstream side and the embankment has a good grass cover.

C. Appurtenant Structures. The spillway weir and sidewalls contained numerous open joints. Some joints between granite blocks in the spillway itself appeared to be quite deep. One of the bedding joints for the cascade near the bottom of the structure was probed to a depth of 2 feet before any mortar was encountered, Photo No. 17. Water was observed spouting under pressure from the upper right end of the spillway. The location is shown in Photo No. 15 between the first and second course of granite.

Water was observed flowing from underneath the stone masonry of the right training wall downstream of the spillway. Photo No. 18. Water was also observed coming down from the left training wall of the spillway. The top of the upstream end of the right training wall has been damaged and needs repointing, Photo No. 8.

The control works, Photos No. 21 and 22, has part of the bar screen missing and the space is filled in with a piece of chainlink fencing. The timber at the entrance of the control works was only a small portion of what was probably there during the original construction. The concrete in the control area shows deterioration. Seepage was noted downstream of the control works and downstream of the blocked 6-ft. diameter penstock.

The gate valve for the 24-in. reservoir drain pipe has a hand wheel operator which was not at the damsite at the time of inspection. This is apparently done to prevent vandalism. The location of the gate is not easily accessible and is in a dangerous position for operation during high discharges. Water was noted to be coming up in the pool just downstream of the gate valve. The gate is shown in Photos No. 16 and 20.

D. Reservoir Area. The area around Lake Gardner is generally heavy wooded, with the exception of the west shore within 3000 ft. of the dam. In this area, there is considerable residential development. While the slopes are steep, in particular along the flanks of Powwow Hill on the east shore, there is very little probability of a major landslide into the lake which could result in wave overtopping the dam. Furthermore, there were no conditions observed which could cause a sudden increase in sediment load into the reservoir.

E. Downstream Channel. The channel immediately downstream of the spillway is in satisfactory condition. No apron exists but large boulders seem to provide adequate protection from scour during normal flows. The over-banks on both sides of the channel are moderately wooded. Downstream conditions in the Powwow River are shown in Photos No. 23 and 24.

3.2 EVALUATION

Prior to 1977, there had been little or no recent maintenance provided for the Lake Gardner Dam. Although trees on the embankment have since been cut, there are still numerous deficiencies which require prompt action.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

In general, there are no formal operation and maintenance procedures to assure continued maintenance and satisfactory operation of the dam. It was reported that the reservoir drain is kept open during periods of high flow.

4.2 MAINTENANCE OF DAM

There are no established procedures to assure periodic inspection and maintenance of the dam. The embankment for the dam has received little or no maintenance during the past 10 to 20 years, since the project was purchased by the Town of Amesbury. Prior to that time, it is also evident that slopes were not maintained by clearing brush and trees. Many of the trees cut during the past year were several decades old. Little or no recent maintenance to the spillway weir and stone masonry training walls is evident.

4.3 MAINTENANCE OF OPERATING FACILITIES

There is no established procedure for maintenance and operation of the 24-in. reservoir drain, the only operating facility presently in use on the dam. This drain is operated approximately once a year on demand. It appeared to be lubricated at the time of the inspection.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no emergency warning system or emergency preparedness plan in effect for this structure. Town officials reported that they would contact local Civil Defense personnel in the event of an emergency.

4.5 EVALUATION

For a high hazard structure of this size, an annual inspection and maintenance program should be instituted for Lake Gardner Dam. A formal warning system should also be developed for the structure.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

A. Design Data. The Lake Gardner Dam and spillway was reportedly built in 1872. There are no records of this construction pertaining to the hydraulic/hydrologic parameters.

In a summary of a 1925 inspection report, Appendix B-11, the spillway capacity is estimated to be about 2300 cfs with the water surface at the top of the dam. The report notes that "The spillway is in good condition but the capacity is not large and when flowing full the water would be practically at the level of the dam". "...under these conditions, any waves of the height which might be expected on such a reservoir, would wash over the top of dam."

A 1929 Report, Appendix B-25, states that the top of the dam was raised by three feet and "With the completion of this work the capacity of the spillway to discharge flood waters has been very greatly increased, and the margin of safety against overtopping of the embankment is much greater than before, so that it is believed that the structure is safe from any conditions which can reasonably be expected."

The recommended test flood for the size (intermediate) and hazard potential classification (high) of this dam is the probable maximum flood (PMF).

B. Experience Data. The PMF was determined using Corps of Engineers guidelines. CSM values somewhat below those recommended for flat and coastal areas were used. This was done since: 1.) the drainage area is very flat and consists of about 28 percent ponds, lakes, and swamps and 2.) CSM values for most other drainage basins of similar characteristics are below the suggested values.

On the above basis, the PMF inflow to Lake Attitash and Tuxbury Pond was estimated and routed. The outflow was then added to the PMF of the drainage area between the outlet for these reservoirs and Lake Gardner. The resulting PMF inflow to Lake Gardner was estimated to be 13,300 cfs. After routing based on surcharge storage, the PMF outflow for Lake Gardner is about 13,600 cfs.

C. Visual Observations. Past inspection reports make reference to flashboards. At the time of inspection, no flashboards were

present although the remains of iron pins indicate that flashboards were used in the past.

The stone blocks which form the crest of the spillway appear to be slightly sloped, creating somewhat of a sharp edge weir during low flows. The spillway approach is good, having an estimated slope of 10:1. The downstream face of the spillway is a series of nine steps which serve to dissipate energy during low flows, thus minimizing scour at the toe of the spillway.

The section of the Powwow River immediately downstream of the dam has an estimated slope of 0.001.

D. Overtopping Potential. The maximum spillway capacity with the water surface at the top of dam, El. 88.5, was determined to be 6,660 cfs. Since the test flood is 12,000 cfs, the spillway can only pass 49 percent of the peak outflow and is therefore considered to be inadequate to prevent the dam from overtopping.

E. Evaluation. In the event of an occurrence of a PMF, the estimated depth of flow over the top of dam would be between 1.5 and 2.0 ft.

Using Corps of Engineers Guidelines for Estimating Dam Failure Hydrographs and assuming that a failure would have occurred along the 750 ft. long section of dam, the peak failure outflow is estimated to be 45,000 cfs. The first downstream reach for flood routing was selected to be between Lake Gardner and the wooden dam just downstream of Pond Street, a reach of about 2100 feet. The flood stage for this reach was estimated to be approximately El. 88.0 or a centerline stream depth of about 21 ft. At this stage, severe flooding of homes and commercial properties along the river would result.

The peak failure outflow from this first reach was determined to be 34,000 cfs. The slope of the Powwow River is steep, about 0.07, as it flows from the wooden dam to the tidal portion which forms the confluence with the Merrimack River. However, the channel is quite narrow through this reach with several unprotected sharp bends. A peak flow of 34,000 cfs would overrun the natural channel and cause additional flooding.

In conclusion, the spillway is inadequate to pass the PMF and should the dam be breached and fail, severe downstream flooding would result with probable loss of life and extensive property damage.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF EMBANKMENT STRUCTURAL STABILITY

A. Visual Observations. Although there was severe erosion on the upstream slope and seepage in one area at the toe of the downstream slope, there was no visible evidence of embankment structural instability during the site examinations on 24 May and 18 July 1978.

B. Design and Construction Data. Riprap placed on the upstream slope has failed, possibly because there was an inadequate blanket of granular soil or crushed stone to prevent scour, by wave action, of embankment material through the riprap. The sloughing and instability of the upstream slope has been caused by scour.

A theoretical analysis of the structural stability of the downstream slope was not possible due to the lack of pertinent design and construction data, in particular with reference to the properties of earth materials placed in the embankment. Nevertheless, the embankment is relatively small, with a cross-section relation to lake level which compares favorably with other low embankments which have proven to be safe under static loading conditions.

C. Operating Records. Not applicable.

D. Post-Construction Changes. The only known changes to the embankment cross-section was the work performed in 1929 when the dam was raised approximately 3.5 ft.

E. Seismic Stability. The Lake Gardner Dam is located in Seismic Zone 3, near its boundary with Zone 2. The stability of the downstream slope during an earthquake event is unknown. Stability analyses, by methods using conditional equivalent static loads, should be made during subsequent investigations after soil properties and foundation conditions are determined.

6.2 EVALUATION OF SPILLWAY STRUCTURAL STABILITY

A. Visual Observation. No visual evidence of instability of the spillway weir was observed during the site examination on 18 July 1978. The center of the weir appeared to be at a slightly higher elevation than the ends of the weir. This may have been due to settlement near the abutments. The right training wall shows a slight

projection towards the weir. No movement of other portions of the structures was observed.

B. Design and Construction Data. It was not possible to evaluate the structural stability of the spillway weir based on design or construction data due to the absence of original plans. The cross-section of the spillway is unknown.

C. Operating Records. No information was located that indicated stability problems with the masonry spillway. Available records refer to pointing of joints between stone blocks.

D. Post-Construction Changes. The sidewalls of the spillway were raised about 3.5 ft. after the original design. This work could have subjected the weir to higher forces than those contemplated in the original design.

E. Seismic Stability. It was not possible to determine the seismic stability of the spillway due to the lack of knowledge of the original design. However, the blocks in the cascade have experienced a good deal of loss of mortar from the joints. Therefore, during an earthquake, the blocks may well act as single units separating themselves from the core of the weir. This will lead to a general weakening of the weir.

The ends of the training walls, especially the wall on the right side, have deteriorated. It is probable then that portions of the wall would fail during an earthquake.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 DAM ASSESSMENT

A. Condition. The visual examination of Lake Gardner Dam revealed that the embankment is in fair to poor condition and the spillway in fair condition. While there were no obvious signs of failure or conditions which would warrant urgent remedial treatment, repairs to the embankment should be accomplished promptly. Continued erosion by wave action of the upstream slope would eventually breach the crest of the dam and lead to overtopping during a major flood.

Based on the results of computations included in Appendix D, the spillway is not capable of passing the test flood, which is based on the probable maximum flood, without overtopping the dam.

B. Adequacy of Information. The data available concerning the design and construction of the dam are adequate for a Phase I Investigation when supplemented by field observations.

C. Urgency. The recommended additional investigations and permanent remedial work outlined in Sections 7.2 and 7.3B should be undertaken and completed during the next one to two years. The measures described in Section 7.3A should be implemented by the Owner immediately after receipt of this report.

D. Need for Additional Investigation. Additional investigations are required, as outlined in Section 7.2.

7.2 RECOMMENDATIONS

It is recommended that the Owner engage a registered professional engineer experienced in dam design to undertake the following investigations:

1. An investigation to develop the design, contract drawings and specifications required for permanent reconstruction of the upstream slope of the earth embankment. This investigation should include test pits to examine the condition of wood sheeting installed in 1929. Repairs should include removal of all stumps and their root systems upstream of the cutoff, reconstruction of the embankment to a slope no steeper than 2:1 with compacted semi-pervious earth fill, and provision for slope protection including stone riprap and suitable bedding course.

2. An investigation of the earth embankment right of the spillway to determine its structural stability under static and earthquake loading conditions.
3. An investigation of the masonry spillway to determine its configuration and structural stability under static and seismic loads. The investigation should include an assessment of seepage which was observed at several locations, e. g. at the base of the right training wall and downstream of the gate valve.
4. Additional investigations to determine means of increasing the spillway capacity.

7.3 REMEDIAL MEASURES

A. Alternatives. Until the additional investigations are completed and permanent reconstruction of the earth embankment is accomplished, the Town of Amesbury should prepare to undertake one or all of the following alternative measures for assuring temporarily that the dam will not be overtopped immediately upon receipt of this report:

1. Lowering the lake level by opening the 24-in. reservoir drain valve. The lake level should not be allowed to rise significantly above spillway crest.
2. Constructing a temporary emergency spillway beyond the right (west) end of the embankment. The existing grade already appears to be slightly lower than the top of the dam. It is probable that a broad flat "spillway" could be constructed at relatively little cost in a day or two.
3. Placing earth fill in badly eroded areas on the upstream slope and providing temporary slope protection to prevent erosion by wave action.

Arrangements should be made to monitor weather forecasts, and to engage a contractor on short notice to undertake the work in the event heavy rainfall and snow melt are predicted.

B. Operating and Maintenance Procedures. The following remedial work should be undertaken by the Town of Amesbury in addition to the investigations outlined in Section 7.2:

1. Cut trees which remain at the toe of the downstream slope of the embankment right of the spillway. Trees and brush should

also be removed within 10 ft. of the toe to allow for visual examination of this area for seepage.

2. Place earth fill immediately left (east) of the outlet works, where earth has been eroded to the top of the concrete core wall. Fill used should be a well-graded silty sand and gravel (glacial till) which when compacted will not be readily susceptible to erosion. The upstream area adjacent to the training wall should be riprapped to protect it from wave action. The remainder should be loamed and seeded.
3. Place coarse pervious earth fill at the toe of the embankment adjacent to the downstream end of the right training wall, where erosion from tailwater turbulence has occurred. The fill must be protected from future erosion with heavy stone and suitable bedding.
4. Repoint granite block masonry on the downstream face of the entire spillway structure. Where necessary, repoint training wall stone masonry right and left of the spillway, upstream and downstream.
5. Reset the existing portions of the bar screen and replace the temporary chainlink fence screen with a new section of bar screen.
6. Remove loose concrete, chip out deteriorated concrete and resurface with new concrete, mortar and/or shotcrete at the control structure.
7. Fill animal burrows on downstream embankment.

In addition, the Town should monitor periodically, at least once a week and more frequently when the lake level is above spillway crest, the seepage area on the downstream slope near Sta. 3+50. Evidence of increased flow, boils and/or erosion of sand and silt is cause for immediate action. In such case, the Corps of Engineers should be notified immediately.

In order to provide for long-term operation and maintenance of the dam and for action in the event of an emergency, the Town of Amesbury should also:

1. Prepare a formal program to periodically inspect the dam and to provide routine maintenance. For example, brush and small trees should be removed from the embankment at least once a year.
2. Develop a formal emergency preparedness plan and warning system, in cooperation with local civil defense and police personnel.

APPENDIX A
INSPECTION TEAM ORGANIZATION AND CHECK LIST

	<u>Page No.</u>
<u>VISUAL INSPECTION PARTY ORGANIZATION</u>	1
<u>VISUAL INSPECTION CHECK LIST</u>	
Dam Embankment	2
Outlet Works - Spillway Weir, Approach and Discharge Channel	3
Outlet Works - Reservoir Drain and Gates	4

VISUAL INSPECTION PARTY ORGANIZATION

NATIONAL DAM INSPECTION PROGRAM

Dam: Lake Gardner

Date: 18 July 1978

Time: 0900-1350

Weather: Clear and Warm

Water Surface Elevation Upstream: El. 90.4 (M. L. W. at Mouth
of Merrimac River)

Stream Flow: Unknown

Inspection Party:

Harl P. Aldrich, Jr.

Haley & Aldrich, Inc.

Roger H. Wood

Camp, Dresser & McKee, Inc.

- Soils/Geology

- Structural/Mechanical

Present During Inspection:

Joseph E. Downing, Camp, Dresser & McKee, Inc.

Michael Pacillo, Mass. Department of Public Works (Part-time)

John J. Ward, Supt., D. P. W., Town of Amesbury (Part-time)

George Pace, Chairman, Board of Public Works, Town
of Amesbury (Part-time)

VISUAL INSPECTION CHECK LIST **NATIONAL DAM INSPECTION PROGRAM**

DAM: Lake Gardner

DATE: 18 July 78

AREA EVALUATED	CONDITION
<u>DAM EMBANKMENT</u>	
Crest Elevation	98.5 (M. L. W. at mouth of Merrimac River) according to 1929 C. T. Main Drawing
Current Pool Elevation	90.4 (8'2" below top of concrete on right training wall)
Maximum Impoundment to Date	Unknown
Surface Cracks	None observed
Pavement Condition	No pavement, top of dam is earth, about 9 ft. wide, with sparse grass and weeds
Movement or Settlement of Crest	None observed
Lateral Movement	None observed
Vertical Alignment	Satisfactory (except for erosion at spillway through walls)
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Erosion from foot traffic and rainfall at training walls (see Photos) Embankment at top of concrete "core" wall on left side
Indications of Movement of Structural Items on Slopes	No structural items on slope
Trespassing on Slopes	Frequent, no restrictions
Animal Burrows in Embankment	None observed upstream; several noted at Sta. 3+75 downstream but difficult to observe ground because of brush, logs/stumps and grass
Vegetation on Embankment	Stumps of large trees (hardwood) up to 36-in. diameter; stumps 1 to 3 ft. above ground. Some dead brush, otherwise slopes bare
Sloughing or Erosion of Slopes or Abutments	At right training wall, top of embankment 7 in. below top of concrete; at left wall, about 18 in. below top of concrete. Upstream slope, especially within 250 ft. of spillway, in active state of erosion, partially from wave action and partially from foot traffic and rainfall.

FILE NO. 4160

HALEY & ALDRICH, INC.
CAMBRIDGE, MASSACHUSETTS

VISUAL INSPECTION CHECK LIST **NATIONAL DAM INSPECTION PROGRAM**

DAM: Lake Gardner DATE: 18 July 78

AREA EVALUATED	CONDITION
Rock Slope Protection - Riprap Failures Unusual Movement or Cracking at or near Toes Unusual Embankment or Downstream Seepage Piping or Boils Foundation Drainage Features Toe Drains Instrumentation Systems	No riprap on slope; numerous large boulders at foot of upstream slope, at water line, except where erosion has occurred None observed Seepage on downstream slope between Sta. Sta. 2+80 and 4+00. (See report) No erosion noted. None observed None None None
<u>OUTLET WORKS - SPILLWAY</u> <u>WEIR, APPROACH AND</u> <u>DISCHARGE CHANNELS</u>	
a. <u>Approach Channel</u>	
General Condition Loose Rock Overhanging Channel Trees Overhanging Channel Floor of Approach Channel	Good Not applicable None Sandy bottom, slope 10 horizontal to 1 vertical
b. <u>Weir and Training Walls</u>	
General Condition of Masonry Rust or Staining Spalling	Open joints in weir granite masonry; probed to 2-ft. depth max.; water observed spouting under pressure upper courses right side; open joints in right and left training walls; upstream and downstream ends of right training wall deteriorated. Lichen growth on right walls, marine moss on cascade Not applicable

FILE NO. 4160

VISUAL INSPECTION CHECK LIST NATIONAL DAM INSPECTION PROGRAM

DAM: Lake Gardner

DATE: 18 July 78

AREA EVALUATED	CONDITION
Any Visible Reinforcing Any Seepage or Efflorescence	Not applicable Flow of water downstream of cascade at bottom of right training wall and downstream of cascade at left side; escaping water under pressure at upper courses of right end of weir; water surfacing adjacent to old power house, just downstream of 24-in. gate valve
<u>c. Discharge Channel</u>	
General Condition	Good (streambed of Powwow River)
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	None adjacent to spillway; wooded downstream (see photos)
Floor of Channel	Some scouring adjacent to spillway; cobbles downstream of scour; rock and timber debris in channel. (See also seepage comment under "b".)
Other Obstructions	None of significance
<u>OUTLET WORKS - RESERVOIR DRAIN AND GATES</u>	
<u>a. Masonry and Structural</u>	
General Condition	Fair to good, concrete somewhat deteriorated; portion of bar screen missing - replaced with chain link fencing; most timber planking missing at entrance to structure
Condition of Joints	Need repointing
Visible Reinforcing	Not applicable
Rusting or Staining of Concrete	None observed
Any Seepage or Efflorescence	Seepage at downstream end of control structure and downstream end of blocked conduit

FILE NO. 4160

HALEY & ALDRICH, INC.
CAMBRIDGE, MASSACHUSETTS

**VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM**

DAM: Lake Gardner

DATE: 18 July 78

AREA EVALUATED	CONDITION
Unusual Seepage or Leaks in Gate Chamber	Water exiting in pool just downstream of 24-in. reservoir drain gate valve
b. <u>Mechanical and Electrical</u>	(No electrical facilities)
Service Gates	24-in. gate valve downstream of weir, left side; operative; leaking slightly 6 ft. by 6 ft. inoperative sluice gate, left side, which empties into a 6-ft. diam- eter penstock which is plugged with con- crete at downstream end

FILE NO. 4160

HALEY & ALDRICH, INC.
CAMBRIDGE, MASSACHUSETTS

A-5

APPENDIX B
LIST OF AVAILABLE DOCUMENTS AND
PRIOR INSPECTION REPORTS

	<u>Page No.</u>
<u>LIST OF AVAILABLE DOCUMENTS</u>	1
<u>DOCUMENTS</u>	
"Plan and Cross-Sections of Lake Gardner Dam on 21 January 1929" by R. R. Evans, Essex County Engineer	3
Report from Sanborn and Bogert, Engineers, to R. R. Evans, Essex County Engineer, dated 29 January 1929	3
"Repairs to Gardner Lake Dam Plans and Sections" by Charles T. Main, Inc., Boston, MA, dated 2 April 1929	9
<u>PRIOR INSPECTION REPORTS</u>	
Report on the 28 October 1916 inspection by the Essex County Engineering Department	10
Summary reports on the five inspections from 6 May 1929 to 21 August 1929 by the Essex County Engineering Department	11
Letter report on the 11 inspections from 6 May 1929 to 21 August 1929 by the Essex County Engineering Department during the 1929 repairs to the dam	13
Summary reports on the 25 inspections from 9 October 1931 to 23 January 1967 by the Essex County Engineering Department	25
8 June 1971 report by the Mass. Department of Public Works	31

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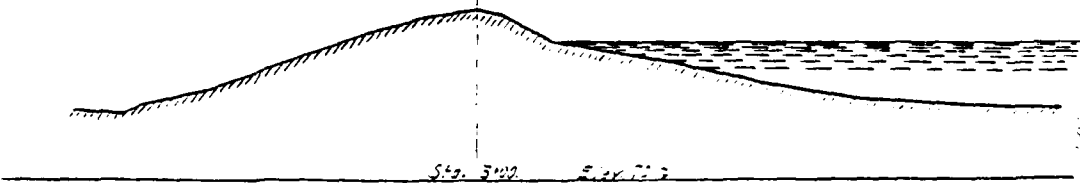
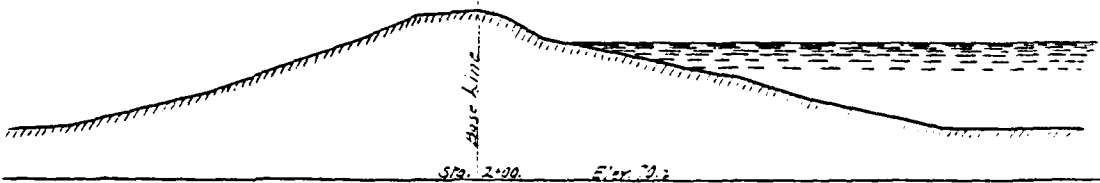
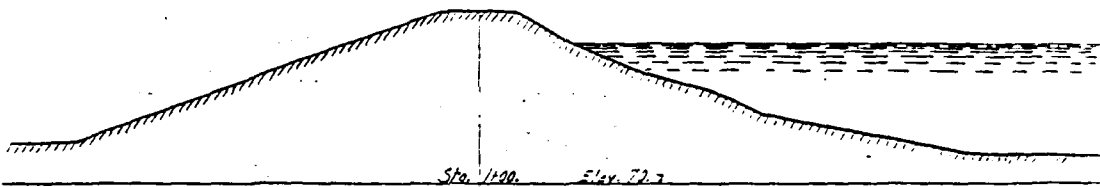
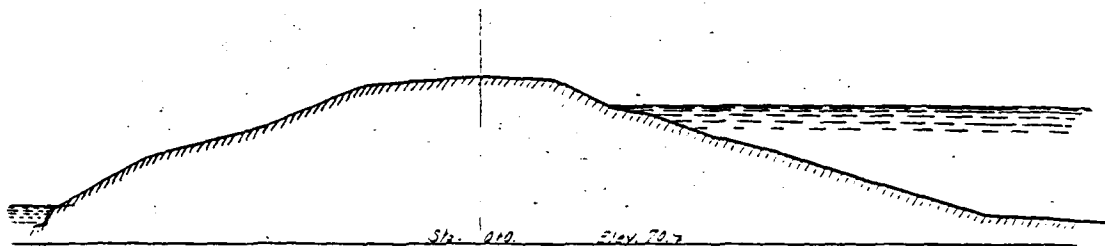
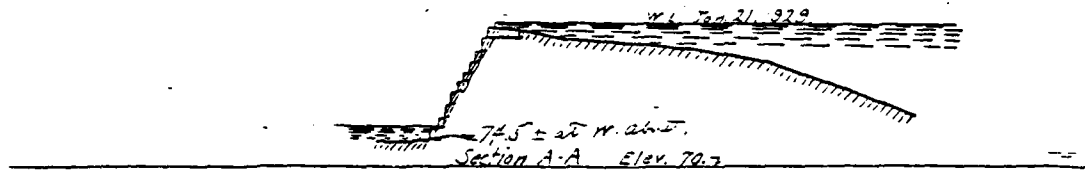
PRIOR INSPECTION REPORTS (Continued)

13 August 1973 report by the Mass. Department of Public Works	32
15 August 1975 report by the Mass. Department of Public Works	36
1 July 1977 report by the Mass. Department of Environmental Quality Engineering	40
23-24 May 1978 report by the Department of the Army, New England Division, Corps of Engineers	47
24 May 1978 report by Haley & Aldrich, Inc.	51

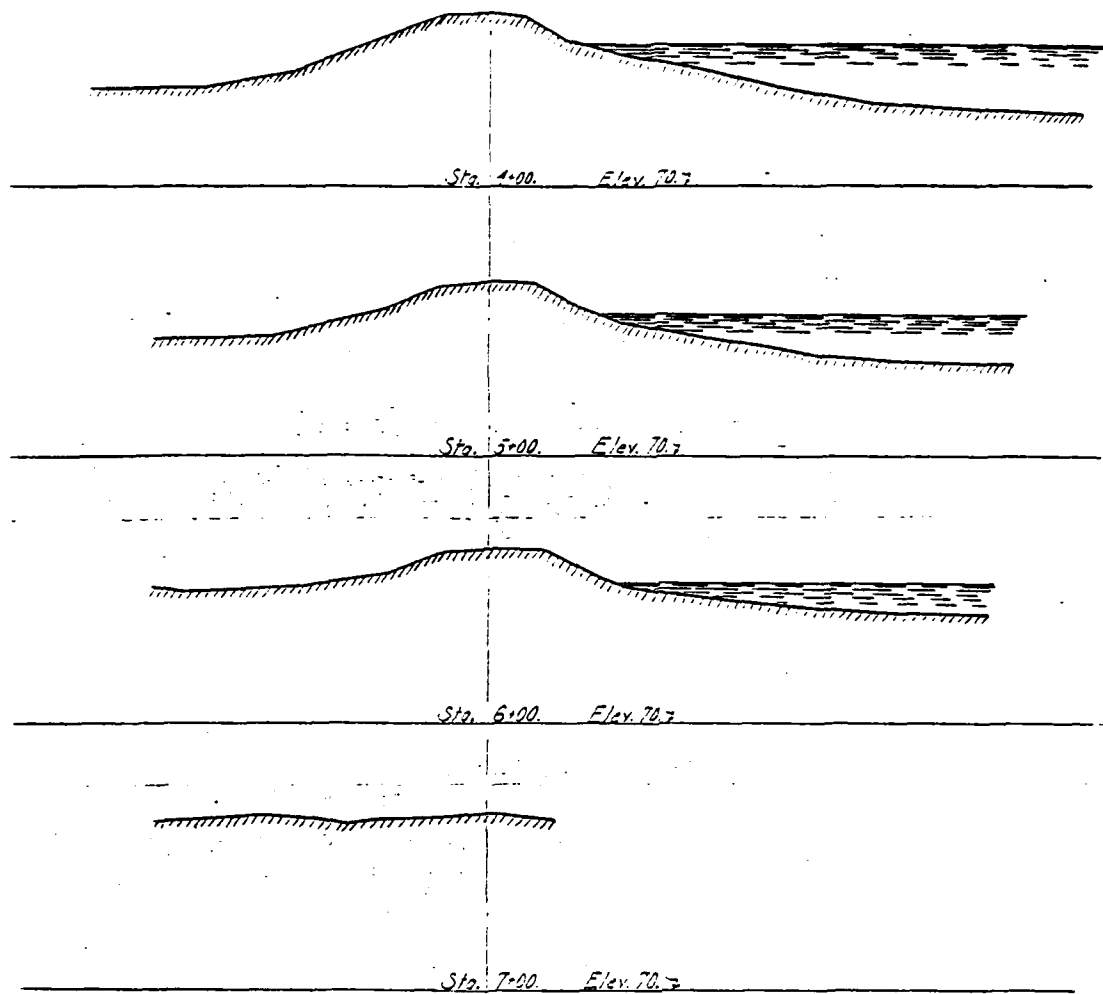
LIST OF AVAILABLE DOCUMENTS
LAKE GARDNER DAM

<u>DOCUMENT</u>	<u>CONTENTS</u>	<u>LOCATION</u>
"Lake Gardner Dam, Amesbury (Notes on interview)" by R. R. Evans, Essex County Engineer, dated 18 January 1929	Statements on original dam construction and water level history by two Amesbury residents	Essex County Engineers Office, 32 Federal Street, Salem MA
Letter from Charles T. Main, Engineer, to Henry B. Wood, Owner, dated 24 November 1917	Information regarding the water power utilized by the Merrimac Valley Power & Building Company from Lake Gardner	Essex County Engineers Office, 32 Federal Street, Salem, MA
Letter from Charles T. Main, Engineer, to R. R. Evans, Essex County Engineer, dated 25 November 1925	Estimated flood flows and spillway capacity of Lake Gardner Dam	Essex County Engineers Office, 32 Federal Street, Salem, MA
Letter from Merrimack Valley Power and Buildings Company to Mass. County Commissioners, Salem, MA, dated 1 November 1926	Summary of 1926 repairs to Lake Gardner Dam spillway and embankment	Essex County Engineers Office, 32 Federal Street, Salem, MA
Summary of 19 November 1926 meeting with Owner, Consulting Engineer, and County Engineer	Discussion of construction materials and adequacy of 1926 repairs	Essex County Engineers Office, 32 Federal Street, Salem, MA

<u>DOCUMENT</u>	<u>CONTENTS</u>	<u>LOCATION</u>
"Plan and Cross-sections of Lake Gardner Dam on 21 January 1929" by R. R. Evan, Essex County Engineer	Plan, elevation, and nine cross-sections of Lake Gardner Dam before 1929 repairs	Essex County Engineers Office, 32 Federal Street, Salem, MA
Report from Sanborn and Bo- ger, Engineers, to R. R. Evan, Essex County Engineer, dated 29 January 1929	Report of engineering studies and recommendations for 1929 modifications of Lake Gardner Dam	Essex County Engineers Office, 32 Federal Street Salem, MA
"Repairs to Gardner Lake Dam Plans and Sections" by Charles T. Main, Inc., Boston, MA, dated 2 April 1929	Contract drawing for 1929 modi- fication and repairs	Essex County Engineers Office, 32 Federal Street, Salem, MA
"Specifications for Construction Work and Materials for Repairs to Gardner Lake Dam", by Charles T. Main, Inc., Boston, MA, 1929	Contract specifications for 1929 modification and repairs	Essex County Engineers Office, 32 Federal Street, Salem, MA



0 20
Scale, ft.



Cross Sections Lake Gardner Dam
Amesbury, Mass.

Scale 1"=20'

0 20'

check scale

January 29, 1929.

Mr. Robert R. Evans, County Engineer
County of Essex
Salem, Mass.

Dear Sir:

Report on Lake Gardner Dam
Amesbury, Mass.

This report is written in reply to your request for an opinion on the condition of the Lake Gardner Dam of which I made an examination with you on December 21, 1928. At that time we also examined the course and outlet of the Power River on which the dam is located, and visited the several storage dams on this watershed.

Studies

I have examined the topographic map of the watershed area, various records of rainfall and run-off on the watershed of this stream and other records of similar character in the New England area. I have also studied the photographs and cross sections of the dam taken by your office and believe that all other pertinent data relating to the case have been considered.

Watershed Area

The watershed of the stream above the dam has an area of about 30 square miles. Most of this area is quite flat with numerous ponds and opportunities for storage. The available history of the stream indicates that the run-off has never been of an exceptional amount.

Mr. Robert Z. Evans, County Engineer - 3 -

Flood Record

At the same time we do not find any history of extraordinarily high rainfall on this area.

In view of all the circumstances we believe that the discharge capacity of the present outlet structures, which it is estimated could discharge a flood of 2300 cubic feet per second, would be inadequate in case of an extraordinary rainfall such as that causing the flood in Vermont in November 1907. The storm causing this high run-off is not of an uncommon type as numerous storms of this character have visited the New York and New England area within the past one hundred years. A similar storm in November 1920 visited the Catskill area and showed high concentrations of precipitation in certain parts of the watershed.

Such exceptional rains are due to the meeting of moisture laden tropical air flowing northward against masses of cold air from the polar regions, with the result that the moisture laden warm air representing an area of low pressure drops its moisture because of meeting the barrier of cold air.

The main point is that such a condition may develop in any part of the New England area irrespective of topographical elevation, resulting in very great rainfall concentration on the watershed.

Conclusion

In view of the possibility of exceptional floods greater than anything previously recorded from the watershed of the Bowdoin River, we believe that a greater discharge capacity than the 2300 cubic feet per second now available should be provided at Lake Gardner dam.

To that end, we recommend that the earth embankments on either side of the spillway and the masonry wing walls at the spillway be raised to El. 90.5, with a top width of the earth embankment of at least 10 feet; we recommend that a masonry core wall at least 8 inches thick,

Mr. Robert R. Evans, County Engineer - 3 -

or a creosoted yellow pine core wall at least 6 inches thick of tongue and groove material to be placed in the upper part of the embankment, with the bottom of the core wall at least as low as the top of the spillway and extending to El. 97. The new embankment slopes should be top soiled and graded or otherwise protected against scour.

The masonry of the spillway should be well pointed up and grouted to stop all leakage through this portion of the structure. A substantial masonry apron should be provided at the base of the spillway masonry.

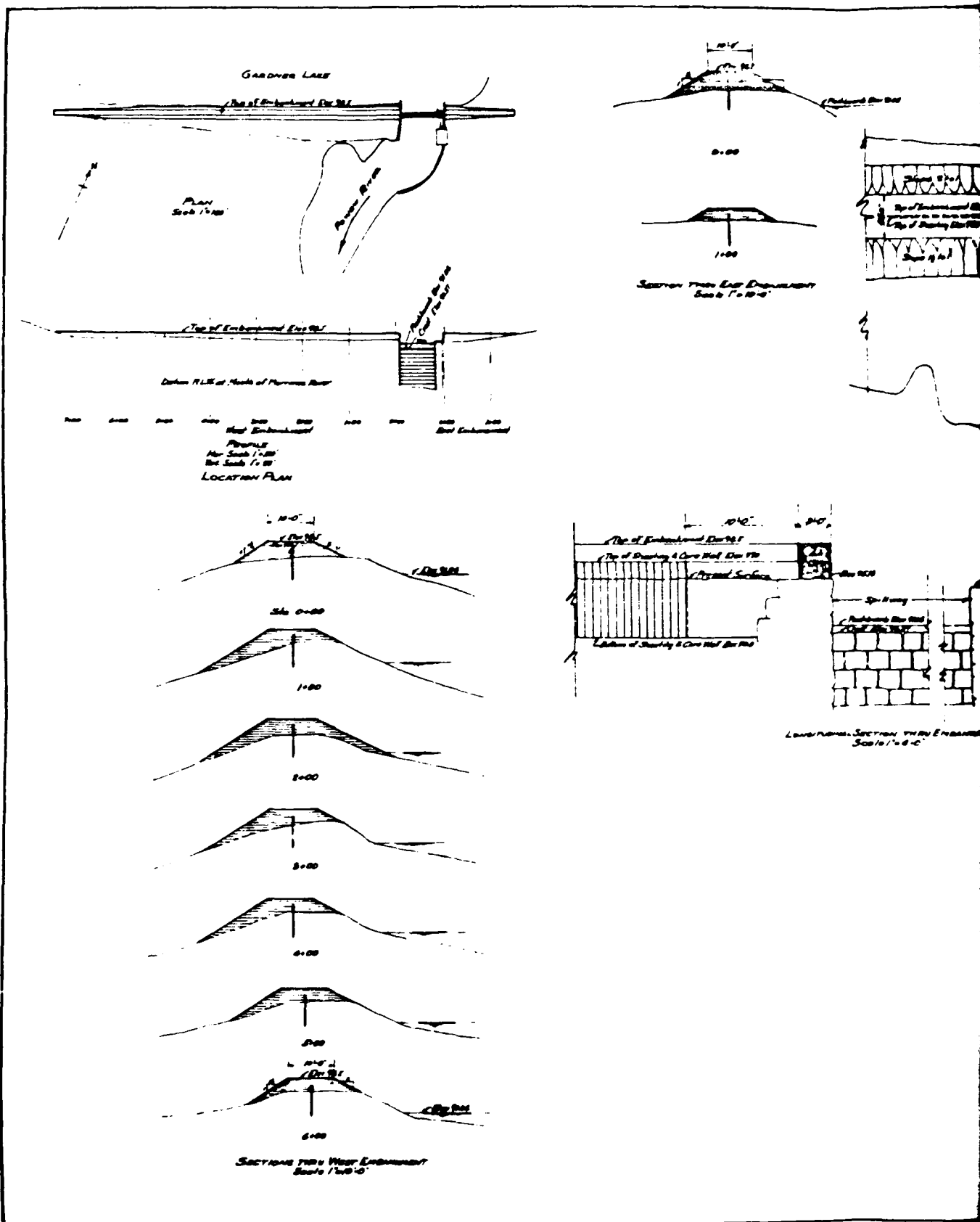
We estimate that the provisions recommended would permit the passage of any flood which might be expected to visit the watershed at any time within the next fifty years. We recommend that the construction indicated be carried out forthwith.

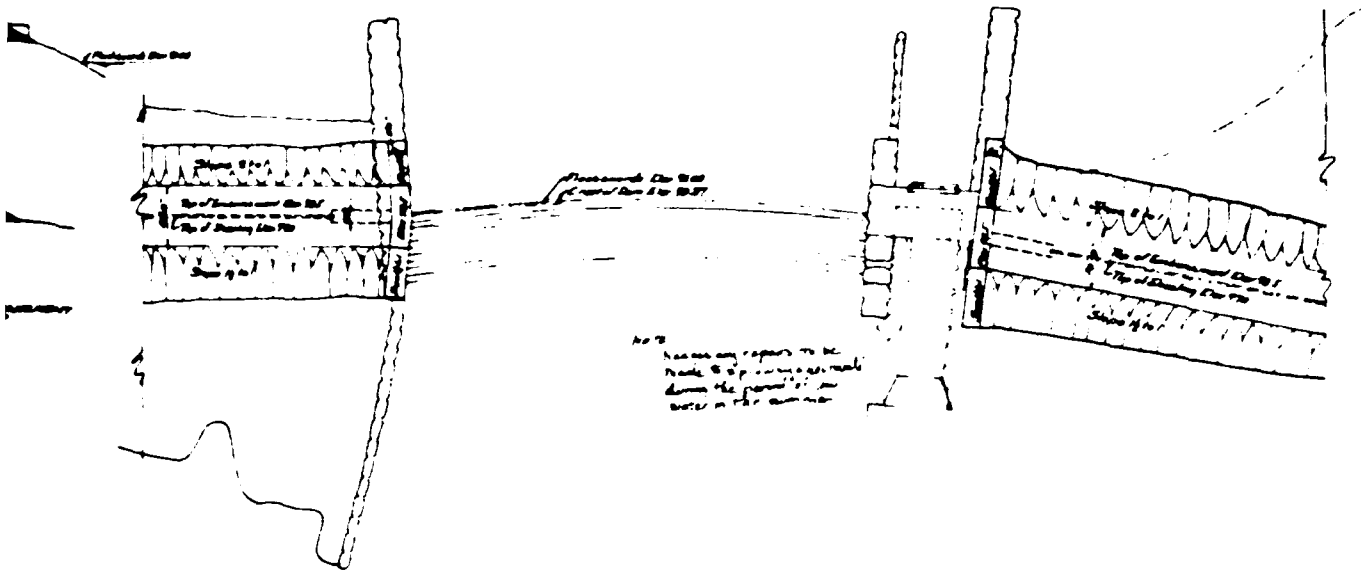
Yours very truly,

SANBORN AND BOGERT

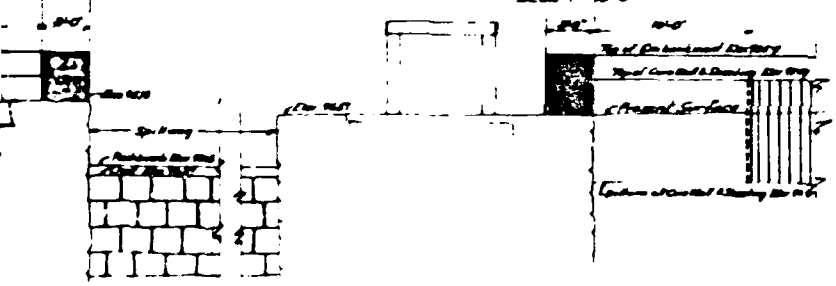
JTS:K

FILE 4160 B 26





PLAN OF SPILLWAY & ABUTMENT
Scale 1"=10'-0"



LONGITUDINAL SECTION THROUGH SPILLWAY & ABUTMENT
Scale 1"=10'-0"

Approved, subject to provisions of
decree of April 12, 1929

Chas. T. Main
Engineer

County
Commissioner

COUNTY OF ESSEX
2418
ENGINEER'S OFFICE

MERRIMACK VALLEY POWER & BUILDINGS COMPANY AMESBURY, MASS. REPAIRS TO GARDEN LANE DAM PLANS & SECTIONS	
CHAS. T. MAIN, INC., ENGINEERS 201, Commercial St. Boston, Mass. U.S.A.	
REVISIONS	
Drawn by	Scale 1"=10'-0"
Checked by	Date Apr. 6, 1930
579-44	

O 101-5C
D 7 R S P

COUNTY OF ESSEX, MASSACHUSETTS
ENGINEERING DEPARTMENT
Inspection of Dams, Reservoirs, and Stand Pipes

O 101-5C
SUB NUMBER
D 7 R S P
Neg. No. 2113

Inspector A. E. Woodbury Date Feb 28, 1916 *Classification 1
City or Town Amesbury Location Lake Gardner (outlet)

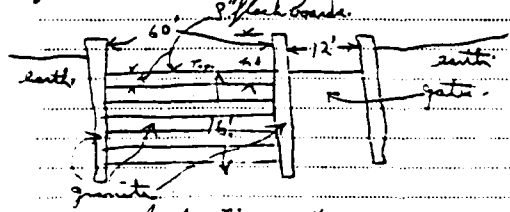
Owner Merima Valley Power & Light Co. Use Ice & Pleasure storage at present
Include such details as cores, cut off walls, paving, masonry, kind of cement, (and or port.) etc.

Material and Type Earth with willow trees along front face granite granite spillway
(brick core wall with cement joints?)

Elevations in feet: above (+) or below (-) full pond or reservoir level. (Cross out what does not apply.)
For Dam
Bed of stream below 2' Bottom of pond Bottom of spillway Top of dam Top of flash boards
For Res. or S. P.
Ground surface below Bottom of ice Level of over flow pipe Top of ice
For dam
Length in ft. 850'± Top width in ft. 12' Pond area Area of watershed
For Res. or S. P.
Inside dimensions Capacity covered open
Length of overflow or spillway Outlet pipes (size and nature)
Stand pipe thickness at base diam of river head
Foundation and details of construction

Constructed by and date Hamilton Woolen Co. (Gardner Tree) 1872
Recent repairs and date
Evidence of leakage Some slight between granite steps
Condition Fair S. P. when painted
Topography of country below Narrow river
Nature, extent, proximity, etc. of buildings, roads or other property in danger if failure should occur Thickly populated with a lot of houses & buildings & streets would be damaged
Plans and data secured or available

Use separate sheet for sketches if necessary.
Notes, sketches, sections, etc. They are working on cofferdams at present, they intend to take out old gate & put in a penstock & turbine & generate power for mills below (also) Chas. J. Main Esq. 201 Devonshire St Boston Mass. Blackburn Eng. in L.



also 1. spillway up to 10 in. of water over - in 3 days in winter
*Severity as to probable damage in case of failure. 3 slight. 2 moderate. 1 serious.

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1917, March 26. Watershed 50.0 sq. m. Max. Ht. 15.0 ft. Apparent condition, Fair.

1925, Nov. 18. R. R. Evans, Insp. At the south end of Lake Gardner there is a long earth dam of considerable height and a masonry spill way. The earth dam was originally probably protected to some extent by rock on the pond side and there is a line of willow trees which apparently were at one time at about the toe of the slope, but the bank has been much cut away by the wave action and this cutting at one or two points has reached nearly to the center of the dam. Just what, if any, core wall there is in the dam seems to be in doubt, but is important to know as in case there be no wall or it be of insufficient height the washing which has taken place to date is much more serious than if the wall proves to be sufficient. I have written to the Power Company asking information and calling attention to the need of repairs in any case and on the 27th of November the County Commissioners visited the dam with me and viewed the conditions. The spill way is in good condition but the capacity is not large and when flowing full the water would be practically at the level of the top of the dam. This dam is an important structure situated as it is, only a short distance above the business section of the town of Amesbury, and holding back such a large body of water. Mr. Uhl estimates the discharge of the spill way at approximately twenty three hundred cubic feet a second or about forty six cubic feet a second per square mile of drainage area, but under these conditions any waves of the height which might be expected on such a reservoir would wash over the top of the dam.

1925, Dec. 4. R. R. Evans, Insp. A visit to the dam following a heavy rain seems to bear out the statement that the watershed is very slow.

1925 Report to Co. Comm. At the south end of Lake Gardner there is a long earth dam of considerable height and a masonry spillway. The earth dam was originally probably protected to some extent by rock on the pond side and there is a line of willow trees which apparently were at one time at about the toe of the slope, but the bank has been much cut away by the wave action and this cutting at one or two points has reached nearly to the center of the dam. Just what, if any, core wall there is in the dam seems to be in doubt, but is important to know as in case there be no wall or it be of insufficient height the washing which has taken place to date is much more serious than if the wall proves to be sufficient. I have written to the Power Co. asking information and calling attention to the need of repairs in any case and on the 27th of November the County Commissioners visited the dam with me and viewed the conditions. The spillway is in good condition but the capacity is not large and when flowing full the water would be practically at the level of the top of the dam. This dam is an important structure situated as it is, only a short distance above the business section of the town of Amesbury, and holding back such a large body of water. December 4, 3:30 P. M., I visited the dam in a heavy rain storm which had lasted all of the previous day. Found water level about one foot over the crest of stone spillway, and about half of flashboards down, these flashboards being apparently nine inches high. The wind is diagonally across the pond from the north-east, so that waves are small only a few inches high, but are, nevertheless, washing the earth embankment a very little where it is already partially cut away. Records of

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rainfall from the City Engineer's office at Haverhill show a total of 1.31 inches up to 8:00 A. M. today practically all within twenty four hours, and 0.43 inches since then. Inquiry from Mr. Wood of the W. V. P. & B. Co. shows that waterwheel at Lake Gardner has not been in use today due to a break. There is no frost in the ground which up to the present storm was comparatively dry.

1926, Oct. 15. R. R. Evans, Insp. to ascertain if any repairs have been made since last year. Found that nothing has been done toward filling in the embankment. The water today is some two or three feet below the top of the flash boards. These flash boards are practically seven inches high, varying slightly with no water flowing over the top of the dam. A leak shows in the second course above the pool level near the east end of the dam. A stream of water which would average an inch in diameter is spurting out of the vertical joint between two of the face stones. It seems to be localized at this point and does not show any seepage around it so far as I can see. On the spill way bank of the ledge stone forming the over flow, tar or asphalt has been placed at some time in the past to make the joints tight. It would seem that the washing away of the embankment has proceeded a little during the past year but not enough to be noticable or even to state positively that it is a fact. A strong wind was blowing down the pond at the time of my visit and the waves were running about one foot high from crest to trough. They do not reach the embankment at the present stage of the water.

1927, Jan. 4. R. R. Evans, Insp. Visited the dam with Mr. Wood, and found that the work of filling in the portions which had been washed out has been completed as far as the company intends to go the present season. Although I had supposed that I was in touch with this job so that I would be able to see the material going in, the job was completed much sooner than I had understood, so that I did not see the material being placed.

There is considerable snow over the fill now and it is frozen so that it would seem to be useless to attempt to do any more under present conditions. I should judge that the general level of the dam on the side next the water has been raised about eighteen (18) inches over the old top of the dam, and the fill has been widened several feet on that side. I drove to the pit from which the material was taken after leaving the work and although much is hidden by the snow, it is possible to see some parts of the banks, from which I judge that there was a great deal of rock in the fill and some fairly loose sand but that, as taken out by the steam shovel, there would be enough loam included to make a fairly tight material. There are too many stone for a dam if it were to be built entirely new, but for the filling in of these holes which had been washed out I believe they will prove of no disadvantage. From what Mr. Wood told me, I do not believe that much compacting of the fill was done except the trucking over it after a large part of it had been placed, not in thin layers. Mr. Wood states that the trucks cut into the top of the old dam very badly so that it was only with great difficulty that they were able to haul the material out on to the embankment. I have suggested to Mr. Wood that the fill will probably require attention in the spring and that at that time it should be brought up higher but I do not believe that anything can be done to help matters now. I urged upon him the necessity of drawing down the water in advance of floods to reduce the depth of over flow in times of floods and this he says he will do. He would naturally do it to utilize as much water as possible.

August 23, 1929.

To the Commissioners of Essex County:

Gentlemen:

In the matter of the alterations and repairs made to the Lake Gardner Dam on the Powow River in Amesbury, in accordance with plans and specifications approved by the Commissioners, I herewith make further report as follows:

The work of making these repairs was begun early in May and has now been completed. I have made frequent visits to the dam during the progress of the work, and am satisfied that the work has been done in accordance with the plans and specifications. These visits were made on the following dates: May 6, 7, 9, 10, 15 and 25, June 4 and 13, July 5 and 23, and August 21, at which latter date the work was found complete.

The conditions of your approval interpreting the requirements of the specifications as approved in regard to cresosoting the sheet piling and as to the riprap were followed, and the company used sheet piling treated with dead oil of coal tar by the empty cell process with at least six pounds of cresote retained, and the riprap as deposited apparently fully meets your requirements.

1929
In the matter of repairs to the spillway, details of which were left for further consideration in your approval, Mr. Sanborn desired to personally view the conditions here at low water stages, and visited the work on July 5th, at which time the owners of the dam had drawn down the water in the pool below the dam so as to reveal the foundation conditions as much as possible. Mr. Sanborn made careful examination of these and his recommendations have been followed out.

A representative of the Charles T. Main Company has frequently visited the work, and for a considerable time an inspector was employed by the owners to be constantly on the work to make sure that the work of placing the sheet piling, the back filling, the embankment and the riprap was done in accordance with the specifications. The Contractor for the work was R. G. Watkins of Amesbury.

I would, therefore, report that the work has been done and completed in accordance with the plans and specifications approved by you.

Respectfully submitted,

County Engineer.

D. T. AMESBURY

- 1929 -

INSPECTIONS OF REPAIRS AND ALTERATIONS

OF

LAKE GARDNER DAM

By

ROBERT R. EVANS

1929

Report of Inspection.

I visited the dam about 4:00 P.M. May 5, 1923. Creosoted plank for the cut-off wall has been delivered and distributed along the dam. It seems to be well filled with creosote. At the east end of the dam the contractor's men (R.G. Watkins of Amesbury) have set up the forms for raising the end wall of the spillway and for the cut-off wall extending easterly to lap the creosoted sheeting. They have uncovered an old brick wall built for this same purpose, apparently, which extends from the granite masonry end wall easterly at about the center line of the embankment. This wall is about 17 feet in length and the top is about 13 inches below the top of the granite masonry of the end wall, which was substantially at the elevation of the top of the dam. The wall is 12 inches thick and there is a groove in the end of it, perhaps 2 inches deep where the plank cut-off of the original dam joined it. Remains of this old plank cut-off are visible, but so far gone near the top portion which has been uncovered, that it is difficult to tell whether it was of a 2 inch or 3 inch plank. Easterly from the end of the old brick wall a trench is being excavated for the new creosoted plank which are 3 inches thick and tongue ^{and} grooved. Two plank have been set up so that the concrete may be poured around them. These two are not down to the grade required, but lap a foot or more behind the brick wall. As the end of the cut-off wall is 10 feet from the end wall of the dam, there will be some 7 feet of planking over-lapping this old brick wall and set close against it on the side next the water. Some effort has been made to clear out the small stones from the top of the old end wall so that the concrete will work down into the voids and properly bond to it.

I suggested to the foreman that a few of the smaller stones remaining could, with advantage, be so removed. The new concrete cut-

off wall laps a foot or more below the top of the brick wall extending down behind it for that distance, and the new wall, being 2 feet thick, the front half of it rests on the top of the old brick wall.

I visited the dam about 4:30 P. M., May 7, 1929. The concrete end wall and the concrete cut-off at the east end of the dam have been coured and concrete, so far as can be seen, seems to be of good quality. The creosoted plank (3" x 6" tongue and grooved plank) have been set up for about 60 feet in length, some 7 feet of which is behind the old brick cut-off wall, and the end plank is cast into the end of the concrete wall. At a point about 25 feet from the end of the cut-off wall, the top of the creosoted plank is about one foot higher, and from that point runs down to a batter board which has been placed about 100 feet from the spillway. At this point where the planking is high, the dam on the lower side is a little above the natural surface. Apparently material for the dam was excavated from the hillside on the east, as an extensive excavation is visible there, and the high point in the sheeting is at about the point where the contour on the original hillside at elevation of the top of the spillway would have crossed the site of the dam. Apparently some mistake has been made, and I called Mr. Watkins by telephone and reported it. He is positive that the batter board is correct for the elevation for the top of the sheeting, and that the fill goes 18 inches above it, but the top of the concrete cut-off wall has not been carried to this height. At the end of the sheeting which has been placed, I saw a few pieces put in and the bottom, which is wet, is soft enough so that these are easily driven down for about 3 inches to a foot below the bottom of the trench. The workmen say that the trench was not wet in the body of the dam. The water is running down from the hillside, the excavation which I saw being in the natural soil. I cautioned the workmen against placing sods in the trench.

fill. Some tamping was being done, and the material is very moist. The sheeting is placed close together, but not wedged, and the end is not pointed in any way, as very little driving is being done.

By telephone, May 3, called attention of Mr. Rose at Charles T. Main's office to apparent error of some sort, and he will visit the work and determine what is wrong.

May 3, visited the dam about 10 A.M. and found Mr. Rose there. He was taking levels to check up the work when I arrived and finds that the top of the sheeting is substantially to the right grade from a point about twenty five feet from the end of the cut-off wall easterly but that some of the plank near the cut-off wall are low. This does not seem to be serious. He also finds that the top of the concrete addition to the end wall and the concrete cut-off wall are each nearly 6 inches below required grade. He will add 6 inches to the height of the walls after concrete has set and will try to get an effective bond.. Agreed with him that it is unnecessary to carry cut-off planking as far east as the trench has been opened up but to stop it at the point where the top of the plank is about a foot above the natural surface. I visited the pit from which material is to be obtained. This is on the south side of the Haverhill Road just west of its junction with *Spurham St* Street and the *foot* of the pit from which the material will probably be obtained is a sand and gravel with considerable clay mixed through it in some portions. At this point there are no very large stone but other portions of the pit are sandy and gravelly without any clay and with many large stones and boulders. The material from this pit seems to be satisfactory for the purpose intended but would not be satisfactory for the portion of the dam below high water.

Mr. Rose is taking up with the company the matter of having an inspector constantly on the work, and I have told him that I think it desirable.

I visited the dam on west side of spillway about 5:00 P. M., May 10, after the workmen had left. The top of the dam on the east side has been plowed in preparation for completing the new fill. On the west side the brick cut-off wall, similar to that on the east, has been uncovered for about 28 feet from the dam and may extend further, as the end was not in sight. Creosoted plank cut-off has been started here and the concrete extension of the end wall has been built up to grade and the 10 foot concrete cut-off built westerly from the end wall, enclosing the end of the creosoted sheeting. I did not see the top of the old masonry before this concrete was poured, but everything appears satisfactory.

I was at the dam about 4:00 P. M., May 15, and met Mr. Wood there. Some 500 feet of plank have been placed in the cut-off on the west side of the spillway. The old brick wall was found to extend about 250 feet from the west wall of the spillway westerly. The top of the wall looks to be somewhat lower at the west end than it is at the spillway, but I am not certain of this. Traces of plank are said to have been found in the excavation for about 500 feet west of the spillway, beyond which point they have found none. Mr. Watkins came on the job before I left and he states that the new plank extend about 2 feet below the bottom of the old plank, and they have followed the line of the old plank with their excavation so that the new line is not exactly straight. These old plank are so far gone that I do not place a great deal of reliance in the above statements and doubt if it would be possible to tell exactly where the bottom of the old plank came. It does seem probable, however, that it did not extend below the present level of the spillway, as the bottom portions in such a case would presumably have been better preserved below the water line. The excavation being made for these plank shows a compact material which requires picking to loosen it and is free from large stones. In many places large roots extend entirely across the trench. The bottom

of the excavation shows no water standing in it, and is only ~~very~~ damp, although it is at about the level of the water in the pond, which is just below the top of the flash boards. There is an inspector on the work for the Power Company, a young man who Mr. Wood tells me worked for Mr. Titcomb, C.E., last year. I suggested to him that they are putting too much earth behind the sheeting before starting to run it. Mr. Watkins states that they intend to put water on the fill to settle it in place.

Mr. Ross at the dam at noon, Saturday, May 25th, for the purpose of looking over the river bed at the foot of the masonry dam. The electric company has drawn down the water for this purpose, so that the entire down-stream face of the dam is exposed, and the water stands at about the level of the bottom of the lowest full course of granite. This, according to the levels taken in January of the present year, would be about elevation 74.50 (Mr. Ross, not having these figures, measured the courses from the spillway down, but apparently made some mistake as the figures do not agree with the above by several feet). Near the westerly side of the dam for about 13 feet out from the west abutment, there is a flat mound of cobble stones, from 6 to 12 inches in diameter, extending about 12 feet down from the top of the dam, the top of this mound being about 18 inches over the water level as it stands today that is, about elevation 76. Eastern from this mound the stones dip down to about the present level of the water with a depth from 18 inches to 2 feet deep immediately below the masonry of the dam, and at this point there is a lower course of stone under the dam extending for a few feet only. Further to the east at about the middle of the stream there is a mound of stone, some of which are much larger than those above mentioned, the largest being probably 3 feet in diameter, and many of them containing one-half a cubic yard or more of stone by estimation. This mound as exposed today extends about 35 feet down from the top of the dam and between the boulders it is packed solid with small cobbles and some stone which look like large stones. I am not able to say positively that there is any cut crop of ledge at this point, but in some places it looks as if there might be. This mound is about 40 feet in width, parallel with the face of the dam, and beyond it to the east abutment there is a mound of small stone about one foot over present water level with a pool less than one foot deep at the toe of the dam just east of mid stream and extending for a few feet along the dam, at which point, also, there is a short stretch of a lower course of stone. These short stretches

es of a lower course at these two points only, might well indicate that an out crop of ledge or boulders was encountered, as otherwise there would seem to be no apparent reason why that course should not have been continuous. The stone in these mounds is somewhat water worn and covered with slime, as would be expected. A careful examination seems to disclose no evidence whatever that there has been any erosion or that the pools have been caused by the scouring action of the water, although it is possible that they may be in part due to this. The highest portion of the mound at mid stream shows in the photographs taken last January, where some of the larger stone are projecting above the water level which was then apparently 18 inches to 2 feet higher than now. It would seem unwise to move any part of the mound at mid stream except that the large scattered boulders might be removed if desirable, since they are so far apart that they offer no protection. The fill is now being made on the west side of the spillway, the cut-off sheeting having been completed. Mr. Rose has a measurement of 235 feet from the west abutment to the west end of the brick core wall which was found in the dam, and the sheeting extends well beyond this practically to the point where the fill runs out on the hillside. The material which is being used seems excellent, having some clay in it, and many small stone, but the large stone had all been thrown out. It is being deposited in a fairly deep layer proceeding from the west end and as there is not room on either side of the sheeting for the trucks to come in. The trucks back in over the completed fill with one wheel on each side of the cut-off, the fill being kept high enough so that the truck body will clear the sheeting. This sheeting projects about 6 inches above the fill, and a caterpillar tractor is being used to roll the material between and outside the wheel tracks. The trucks, of course, are compacting the portion in the wheel tracks very solidly, and the tractor seems to be ^{pushing} the rest of it down to make a good solid fill. Loosening and riprapping will not be commenced until the fill is complete.

Visited the dam at 3:00 P. M. June 4, 1929. About 250 feet in length on the west side from the spillway westerly has been brought up to grade, ready for the loaming. The inspector says that the slope on the water side was completed here, but that the waves have cut out the top of the slope and further fill will be made with the rip-rap, the placing of which is to begin tomorrow morning. The west portion of the embankment is from one foot to two feet below grade and work is progressing, so that the whole fill should be complete within a few days. The small caterpillar tractor was just finishing the rolling of the top of the embankment when I arrived. It seems to be very effective, and the cleats loosen the surface enough so that the layers should bond well together when this is used in the body of the fill. The embankment seems very compact and the material seems good, containing many small stones but no large stones. There was some evidence of a little silty material showing in the last material placed, but I think there is very little of this. The embankment on the east end is said to be complete and looks to be so, but I did not go to this end of the dam. Mr. Rose was at the dam again today, but had left before I came, and is expected again on Thursday, the 6th.

I was at the dam at 3:00 P.M., June 13th, and met Mr. Rose. The fill is complete except for loaming and rip-rapping, the latter being in progress and about half done. The stones are being roughly placed and the thickness of the rip is a foot or more. Where the water had cut into the fill, the inspector states that stone was dumped in without refilling the earth to the line, so that the thickness here is considerably greater. We made a rough test on top of the fill by digging a shallow hole and pouring perhaps a quart of water into it, and found that the water percolated into the earth very slowly. Although not more than two or three inches deep at the center, probably half of it still remained twenty or twenty

five minutes after the test was made. As the day is very hot and the top of the embankment very dry, this would seem to indicate a tight embankment.

Friday, July 5, 1929, met Mr. Sanborn, Mr. Rose, Mr. Watkins and Mr. Wood at the Gardner Lake Dam. The water had been drawn down in the pool below the dam so as to expose the foundation as far as possible and the visit was made especially to give Mr. Sanborn opportunity to see these conditions for himself. He made a close inspection of conditions along the toe of the dam and examined the material in the high places of the river bed just below the dam, and his attention was called to the stone which resemble the ledge in this locality. He also saw the open joints of the dam and of the head walls and the amount of leakage and looked over the riprap facing which has been placed on the up-stream side of the dam, and made a careful examination of the pit from which the material for raising the embankment has largely been obtained except the riprap which has been obtained elsewhere, and which pit is supposed to have been originally formed ^{to drain} with material for the original dam. After seeing all these things, he expresses himself as satisfied, and says that if the large stone in the bed of the river just below the dam be recovered and piled up against the base of the dam so as to make it at least as high for the full length as it now is in the high spots, and if the open joints between the split stone in the dam be thoroughly checked up with pinners and the head walls similarly pinned with stone laid in mortar, he would feel that the structure is satisfactory. The fill and the riprap as it stands meets his approval. The fill shows very hard and the grass is beginning to sprout. Mr. Carson took three photographs while we were there, showing the up-stream face of the dam and its foundations, the top of the spillway looking west with embankment in the distance, and a view from the west shore looking easterly along the dam to show the riprap which has been placed.

At Gardner Lake Dam July 23, late in P. M.

There are no men there and nothing indicates that they have been working today but the joints in the dam and those in the wall on the west side below the dam have been thoroughly chinked up with cinners and small stone. I could not determine that anything had been done towards stopping the leaks. The water is so low, perhaps five or six feet below the spillway, that only the small leaks in the lower portions near the east end are now showing up. Some pointing was done on the wall at the west end of the spillway but the joints in the dam and the west wall below the dam are dry. The east wall below the dam has been chinked up with stone laid in mortar. Nothing apparently has been done toward moving the large stone up against the dam.

August 21 visited the dam about 5:00 P. M. Work is now complete and the Contractor has removed his tools, etc. from the dam. The water is a few inches over the top of the lower course of stone, but it is evident that stone have been placed in the two depressions before mentioned up to about the general level of the bottom of the lowest full course of stone in the dam, and these stone extend some eight or ten feet downstream. I think this would fulfill Mr. Sanborn's requirements as he apparently felt that there was little danger of erosion in the material on which the dam is founded. The west wing wall has been thoroughly chinked up, but there is no mortar in the joints. The east wall has also been chinked up and some mortar has been used here. The water today is four or five feet below the top of the dam and only one leak about ten feet from the east end in the top of the third course from the bottom is in evidence. The leaks around the flume are about the same as on previous visits. The grass on the west embankment is growing well, but there is very little grass on the east embankment.

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See 0101-3-C, 1929, for reports and inspections of repairs and alterations.

1929 Report to Co. Comm. Substantial improvements were made during the year on Lake Gardner Dam on the Powow River. In compliance with the requirements of the Commissioners, the top of the earth embankment forming this dam has now been raised about three feet, and the end walls of the spillway carried up to a corresponding height. A cutoff wall consisting of creosoted yellow pine plank was placed in the new fill and extended down into the old embankment to the approximate level of the spillway, the top and downstream slope of the embankment were loamed and seeded and are now well grassed over. The up-stream slope of the earth embankment was protected by riprap and repairs at the spillway were made, consisting of pointing some of the walls and re-arranging the riprap at the base of the masonry spillway to protect the foundations from possible scour. With the completion of this work the capacity of the spillway to discharge flood waters has been very greatly increased, and the margin of safety against overtopping of the embankment is much greater than before, so that it is believed that the structure is safe from any conditions which can reasonably be expected.

1931, Oct. 9. C. C. Barker, Insp. Dam at the south end of Lake Gardner on Powow River, owned by the Merrimac Valley Power and Buildings Company is used for power. I gave a copy of the notice to G. E. Nickerson, Manager, who sent Mr. Hudon, foreman, to the dam with me. This dam is just above the thickly settled part of the town, through which the river flows with a steep incline. A great deal of damage would be done and it is very likely there would be loss of life. The earth embankments were raised in 1929 and repairs made, plans of which are on file in the County Engineer's office. The dam is in good condition except there is a great deal of leakage around the spillway through the joints between the granite courses and through the stone walls on each side of the gate chamber at the east end of the spillway. Between the top course and the next course down in the spillway there are some small stones, in some places these are gone. In the 5th course and the 7th course down, two of the granite stones are thrown and tipped out of line. The earth embankments are in good condition. The water level is nearly to the top of the spillway today.

1931, Nov. 5. R. R. Evans, Insp. The earth embankments and the riprap are in good shape, except that immediately adjacent to the west wall some of the riprap is gone and should be replaced. (It may have been removed by boys in order to make it easier to get down into the water at this point.) Several stones in the top course carrying the flash boards are practically unsupported on the face. The condition is much the same in this respect as it was before the repairs were made in 1929, but the records show that pinnars were put in to chink up the openings in the face of the dam at that time. Apparently they have been removed or have fallen out, and this top course should be securely pinned up before cold weather.

1931 Report to Co. Comm. The dam at Lake Gardner was extensively repaired two years ago in accordance with plans approved by the Commissioners, so as to very materially increase the capacity of the spillway and to provide a much greater factor of safety against overtopping. The earth embankment which was placed at that time seems to be in good condition, and the riprap is also in good condition, except immediately adjacent to the end wall of the spillway where it has been partially

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removed. This condition and the need of pinnars in the downstream face of the masonry spillway was called to the attention of the owners in order that they might be able to make these slight repairs in the season of low water.

1933, Sept. 6. C. C. Barker, Insp. Mr. Leavitt inspected this dam with me. I gave a copy of the notice to G. E. Nickerson, Manager. The dam is in good condition, there is very little leakage. The water level is about 1.5 feet below the spillway today. Just under the top course near the center there is a small place where the pinnars are out. These will be put back this fall. The slopes are good and only a few of the paving stone on the upper slope are thrown out. There have been no changes since the last inspection and the conditions are the same.

1933 Report to County Commissioners, safe and in reasonably good condition.

1933 Sept. 24, C.C.Barker, Insp. Mr. Leavitt inspected this dam with me. The water level is about one foot below the crest of the spillway. Near the center of the spillway some of the pinnars are out from under the top course. Also some of the joints in the top course near the center need filling to prevent leakage and washing in back of the stone. Some stones are out in the west wall of the spillway on the lower side near the top. A little fill is needed on the upper side next the spillway wall. There is a little leakage at the penstock and gate at the easterly end of the spillway. The earth slopes are in good condition. Mr. Leavitt says this dam is looked over and any loose stones etc. are replaced and repairs made every fall. A new laundry building is being built just below the dam.

1933 Report to Co. Comm. The dam at the outlet of Lake Gardner, one of the most important dams in the County, extensively repaired a few years ago to your approval, appears to be in fairly good condition and it is believed that the minor repairs which become necessary from time to time are being properly attended to.

1934 July 22, C.C.Barker, Insp. I gave a copy to Mr. Leavitt, Supr. This dam is in good condition except for a little leakage at the easterly end of the spillway the first and second courses from the bottom and also the eighth course, also there is some leakage each side of the gate chamber at the penstock elevation. The west earth embankment is good except that a little earth is gone next the lower west wing wall and some on the upper west wing wall. The conditions are the same and there has been no change. The pond is nearly full.

1937 R.R.Evans, Insp. Visited this dam October 13, 1937 and observed conditions reported by Mr. Barker at time of his inspection. The leakage through the dam is of small amount. There are some well defined leaks near the penstock, but no different, I think, than when I last saw them. The earth embankment immediately adjacent to the walls of the wasteway has been worn down to a depth of a foot or more and should be replaced and protected by paving. The pond is practically full.

1937 Report to Co. Comm. The large tank dam at the outlet of Lake Gardner seems to be in good condition and is apparently closely supervised by the owners. There is some slight washing of the embankment and immediately behind the walls at the spillway this embankment has been worn away to a depth of a foot or more and should be replaced and protected.

Amesbury D. 7

should be protected by paving, or otherwise, against further damage. Leakage through the masonry near the penstock is no more than in the past and is apparently unimportant.

1939 Sept. 3, C.C.Barker, Insp. I gave a copy of the notice to Mr. Nickerson, Manager. I saw Mr. Leavitt, Supt. at the dam. They are repairing the wooden gate and other work in the gate chamber at the penstock east of the spillway. The westerly embankment is slightly washed away in a few places. A few stones are put in the west wing wall down stream side. The up stream west wing wall has been repaired. There is very slight leakage. The water level is 6 feet below the top of the spillway. This dam is in good condition and will be improved when the repairs now being made are finished. There has not been any change.

1939 Oct. 30, R.R.Evans, Insp. Inspected Lake Gardner dam. West of the spillway adjacent to the wall there is some wearing away of the embankment in what is apparently used as a path in climbing up and down the embankment. This has been recently filled in with gravelly material, indicating that attention is being paid to the condition of the structure and the masonry seems to be in good condition. The dam may well be classified as safe and in reasonably good condition.

1939 Report to Co. Comm. Safe and in reasonably good condition.

1941 Oct. 1, C.C.Barker, Insp. I gave a copy of the notice to Mr. Nickerson, Manager, who sent Mr. Taber to the dam with me. This dam is now owned by the Amesbury Electric Light Company. There has been some erosion of the fill back of the westerly wing wall on the upstream side. Some fill and riprap should be placed here and Mr. Nickerson will have this done. There is hardly any leakage. This dam is kept in good condition. The water level is about 4.5 feet below the crest of the spillway.

1941 Report to Co. Comm. Safe and in reasonably good condition.

1943 Sept. 3 S. W. Woodbury, Insp. I gave a copy of the notice to Mr. Nickerson, who did not have a man at the time to send to the dam with me. He gave me keys to the gate, however. There is some leakage in the joints of the three lower courses, also in the walls each side of the penstock. The wearing away of the embankment, at the westerly end near the concrete wall, still goes on. Some slope paving should be placed here to prevent this. New trash racks have been placed since the last inspection. The water level on the gauge was 36.05, or about 0.2 feet below the top of the granite spillway.

1943 Report to Co. Comm. The dam on the outlet of Lake Gardner may be considered safe and in reasonably good condition. A few places on the west embankment need some slight repairs with earth fill and riprap. All repairs are well taken care of by the owners.

1945 Aug. 30, S. W. Woodbury, Insp. I gave a copy of the notice to Mr. Nickerson, Supt., but went to the dam alone. The water level today is 33.3 on gauge. Pond very low. The condition of the dam is the same. Mr. Nickerson said that he would have the embankment at westerly end repaired. This is still wearing away here.

1945 Report to Co. Comm. The dam at the outlet of Lake Gardner may be considered safe and in reasonably good condition. A few repairs are needed on the earth embankment which will be made by the owners.

1947 Oct. 6, S.W. Woodbury, Insp. Gave a copy of the notice to Mr. Crosby for Mr. Nickerson and went to dam alone. No repairs since last inspection. Water level today is 85.5 on gauge or 0.7 below top of spillway. Leaks are same as previously reported. The embankment at the westerly end has not been repaired and is getting very bad. Mr. Crosby says that he will attend to this.

1947 Report to Co. Comm. At the Gardner Lake Dam, contemplated repairs to the embankment at time of last inspection have not been made, but should be made at this time to prevent further erosion. The owners will have this done.

1949, Sept. 29, S.W. Woodbury, Insp. Left a copy of the notice for Mr. Nickerson at his office and went to dam alone. Water level today: 80.8 on gauge. Condition of the dam is the same.

1949 Report to Co. Comm. At the Gardner Lake Dam, a very important dam, repairs should be made to the embankments to prevent further erosion and the possibility of the water cutting through the embankment.

1951 Oct. 18, E.H. Page, Insp. Gave a copy of the notice to Mr. Ledy (New Mgr.) and went to dam alone. Repairs since last inspection: Old steel penstock has been encased in concrete. West wing wall has been pointed up. Water level today: 85.1 on gauge. Leaks: 2 bad leaks through joints in granite near bottom.

1951 Report to Co. Comm. At Gardner Lake Dam the old penstock has been encased in concrete and the west wing wall pointed up with cement mortar. As this is a very important dam, the slopes of the earth embankment should be kept in good condition to prevent any erosion, and repair made to prevent leakage near the bottom of the granite spillway.

1953, Oct. 1, E.H. Page, Insp. (Oct. 8, E.H.P. & J.O.H.) Gave a copy of the notice to Mr. Robbins and went to dam alone. No repairs since last inspection. Water level today: 81+ (cannot read gauge). Leaks through the joints in the granite at the bottom. Condition of the dam is the same. At the westerly wing wall the top of the earth embankment has scoured out and this reduces the freeboard here by about 2 feet. For another 50' - the upstream face of the embankment has scoured badly and should be repaired before high water and it gets any worse and becomes dangerous. There is another bad place about the middle of the dam where the riprap has washed away and the earth had scoured out. The gate was open and they were not using the water for power. A bituminous hot top material had been placed on the upstream side of the spillway to stop some of the leaks.

1953, Report to Co. Comm. At the Lake Gardner outlet, there is some leakage through the granite at the bottom. At the westerly wing wall, the top of the earth embankment has scoured out and this reduces the freeboard by about two feet. There are other places along the earth embankment where there has been erosion which should be repaired. This erosion and scouring is much more serious than the leak in the masonry.

Amesbury D.V.

D. T. Ch. 7

1954 May, E.H. Page & J.O. Harmaala, Insp. Leaks at the gate. Erosion of banks very bad at several places on the upstream slope. Mr. Robbins said he would take care of these slopes at once. Nothing had been done by June 3rd. This is a very long and high dam just above the center of Amesbury and these slopes should be kept in the best of condition before they become really dangerous.

1954, Nov. 5 E.H. Page & J.O. Harmaala, Insp. Gravel has been placed on the pond side of the dam as requested. There appears to be less seepage between joints in granite at the spillway. Flashboards have been removed. Some of the new gravel has washed down. They could use some more fill, preferably tailings or boulders, to retard deterioration due to wave action.

1955, Nov. 21, E.H. Page, Insp. New gate at the flume, more gravel. Elev. of water: 7" above dam. Height of flashboards: 10". A private bathing beach has been made at the easterly end of the dam. Some more gravel has been dumped on the embankment since last inspection. This dam is fenced off now with no trespassing signs. Gate is open.

1955 Report to Co. Comm. At Lake Gardner outlet, there is some leakage through granite at the bottom. A number of loads of gravel have been placed on the upstream face of the embankment and next to the concrete wingwall. This relieves the serious erosion that had taken place and brings the embankment up to grade. The old wooden gate has been replaced with a new creosoted timber gate at the penstock. This is a very important dam and must be kept in the best of repair.

1957 Dec. 3, E.H. Page, Insp. Owner: Merrimack- Essex Electric Light Co. Elev. 85.0 about 3 1/2 feet below top of dam. Leaks: Water very low, but still some leaks in the joints for first 3 courses of granite. Height of flashboards in place 10". Minimum freeboard: 3 feet. No obstructions in spillway. Erosion of Banks: Some - gravel has been dumped in the bad places as recommended. Condition of dam: Good. Elev. of top of spillway 85.5± Could use some more riprap or tailings on upstream side of embankment to hold new gravel fill from washing out.

1957 Report to Co. Comm. At Lake Gardner outlet, water was about three and one-half feet below top of dam at time of inspection. Water leaks through joints in granite, but this is not very serious as the granite itself does not erode. The Electric Company has filled in some of the badly eroded spots in the upstream side of the dam. This gravel should be covered with riprap or stone tailings below the top water level to hold it in place.

1958, January 27, E.H. Page & J.O. Harmaala, Insp. Elevation 87.5 Top of gate is elev. 88.0. Top of dam is about elev. 86.3±

1959, Sept. 14, E.H. Page, Insp. Elev. of water: 12" below flashboards Elev. 86.2. Leaks through the granite as reported. Height of flashboards etc. 12". No obstructions. Some erosion of banks, especially at the spillway. This is due to foot traffic. If it was backfilled with stone or riprap, it might hold. There are some other places which need some attention.

1959 Report to Co. Comm. At Lake Gardner outlet, there is some erosion on the dam next to the westerly end of the spillway. This is due mostly to foot traffic. Some large stones and stone tailings would help this situation. There are a few other places along the embankment. Water elevation 86.2. Water piping through joints in granite of spillway.

Amesbury D. 7

D. 7 Sh. 6

1961, Dec. 5 E.H.P. & P.D.K. Inspec. Elev. of water: 6" below spillway. Some leaks. No flashboards, gate open to powerplant. Condition: same. Brush control on upstream side of dam.

1961 Report to Co. Comm. Lake Gardner Outlet. There is some erosion on the dam next to the westerly end of the spillway. This is due mostly to foot traffic. Some large stones and stone chippings would help this situation. There are a few other places along the embankment. Water piping through joints in granite of spillway. Some brush control on the upstream side of the dam was started recently and should be continued.

1964, Feb. 10. P.D.K. & R.M.G. Inspec. Owner: Amesbury Elec. Light. Possible loss of life in case of failure. Elev. of water 0". Considerable piping in lower four courses. No flashboards. Small hole back of wing wall 25-30' on downstream side. Condition: fair. Both faces of each dam lined with large trees and brush, seepage at toe of downstream side.

1963 report to Co. Comm. Lake Gardner Outlet. There is some erosion on the dam next to the westerly end of the spillway. This is due mostly to foot traffic. Some large stones and stone chippings would help this situation. There are a few other places along the embankment. Water piping through joints in granite of spillway lower four courses. Some brush control on the upstream side of the dam was started recently and should be continued on both sides of the earth dam. A small hole in earth behind easterly wingwall should be filled in.

1965 June 8, 1966. Condition same as in 1963.

1965 Report to Co. Comm. Water was flowing 0/1 feet over 7" flashboards. Gravel has been placed at various spots along the upstream face of the earth dam. Large trees along the west wing wall should be cut down and holes in embankment at wing wall should be filled. Earth is washing away on both upstream and downstream sides at the east wing wall.

1967 Jan. 23, 1968. P.D.K. Inspec. Water was about 6' back from top of dam and is going down behind granite blocks about 20' + from west end of dam. Leaks are evident three or four granite courses from bottom. Brush control should be continued on earth dam.

1967 Report to Co. Comm. At this inspection the water level was about 3 feet from the top of the dam at elevation 86.8 feet on the gauge and the gate valve was open. Water runs behind the granite blocks about 20 feet from the west wingwall and seeps out through the granite blocks about 3 or 4 courses up from the bottom of the dam.

DEPARTMENT OF PUBLIC WORKS
DISTRICT 5

D. 7
AMESBURY
5-5-7-4

REGULATION OF DAMS AND RESERVOIRS
(CHAPTER 253 OF GENERAL LAWS AS AMENDED
BY CHAPTER 305 OF THE ACTS OF 1970)

INSPECTED L.E. WILKINSON DATE 6/8/71 RECLASSIFICATION 1

LOCATION OUTLET OF LAKE GARONER - BEGIN AT WESTERLY

END OF HIGH STREET AT WHITEHALL ROAD - TAKE
WHITEHALL ROAD NORTHWEST 0.10 MI. - DAM IS 500 FEET
EAST BY FOOTPATH. AMESBURY ELECTRIC LIGHT CO.
TOWN OF AMESBURY WATER DEPARTMENT TOWN HALL

USE WATER STORAGE AND PLEASURE BOATING & SWIMMING.

MATERIAL & TYPE EARTH AND GRANITE BLOCK FACE WITH GRANITE
BLOCK SPILLWAY

HEIGHT OF DAM 21 FEET TOP ELEVATION OF DAM _____

DATUM M.S.L. 1929 TOP ELEVATION OF SPILLWAY _____

LENGTH 850 FEET TOP WIDTH 10 to 12 FT. POND AREA _____

VOLUME OF WATER IMPOUNDED _____ GALLONS

CONTRIBUTORY DRAINAGE AREA _____ SQ. MILES _____ ACRES

DESCRIPTION OF SPILLWAY WATER 3 INCHES DEEP OVER GRANITE

SPILLWAY TO-DAY. - NO FLASH BOARDS - WATER IN LAKE @ 86.5 FEET

SOME LEAKING AT WEST END OF CONC WALL AT GATE.

LOWER DOWNSTREAM AREA OF WESTERLY WINGWALL OF SPILLWAY
NEEDS POINTING.

RECOMMENDATIONS DAM IN GENERAL IN EXCELLENT
CONDITION.

* PROBABLE DAMAGE IN CASE OF FAILURE 1. SERIOUS 2. MODERATE 3. SLIGHT

August 24, 1973

Board of Selectmen
Town Hall
Amesbury, Massachusetts

RE: Inspection-Dam#5-5-7-4
Amesbury
Lake Gardner Dam

Gentlemen:

An engineer from the Massachusetts Department of Public Works and Mr. Lavallay of the Amesbury Department of Public Works, have inspected the above dam which is owned by the Town.

The inspection was made in accordance with Chapter 253 of the Massachusetts General Laws, as amended by Chapter 595 of the Acts of 1970.

The results of the inspection indicate that this dam is safe; however, it is strongly recommended that a regular maintenance program be established to keep it from deteriorating. The following conditions were noted that require attention:

1. Grout the granite blocks, as necessary.
2. Serious consideration should be given towards removing the trees from the embankment. If left standing a storm could uproot one or more, thus creating a major breach and failure of the dam, endangering life and property downstream. Conversely, the root system of trees that have been cut down, must be removed and extreme care should be given to backfilling and compacting the embankment so that the integrity of the dam would not be jeopardized.
3. Some erosion of the slopes and along the upstream face, caused by foot traffic, should be corrected.

We call these conditions to your attention now, before they become serious and more expensive to correct.

LPA
LPA/a/s
cc: J. Berkover JHE#5
D. Morgan Dist#5

Very truly yours,

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

INSPECTION REPORT - DAMS AND RESERVOIRS

1. Location: City/Town Amesbury Dam No. 5-5-7-4
 Name of Dam Lake Gardner Inspected By: D. P. Morgan
 Date of Inspection August 13, 1973

2. Owner/s: per Assessors _____ Prev. Inspection _____
 Reg. of Dams _____ Pers. Contact *
 1. Town of Amesbury, Amesbury Town Hall, Amesbury, Massachusetts
 Name: _____ St. & No. _____ City/Town _____ State _____ Tel. No. _____
 2. _____ St. & No. _____ City/Town _____ State _____ Tel. No. _____
 3. _____ St. & No. _____ City/Town _____ State _____ Tel. No. _____

3. Operator (if any) e.g. supervisor, plant manager, appointed by electric owner, appointed by utility owners.
Amesbury D.P.W.
 Name: _____ St. & No. _____ City/Town _____ State _____ Tel. No. _____

4. No. of Pictures taken NONE

5. Degree of Hazard (if dam should fail completely)*
 1. Minor _____ 2. Moderate _____
 3. Severe _____ 4. Disastrous *

* This rating may change as land use changes (future development)

6. Dam's Control: Automatic _____ Manual *
 Operative * Fed. No.
 Comments: Gate Valve

7. Condition of Dam: Condition:
 1. Good _____ 2. Minor Deterioration *
 3. Major Deterioration _____ 4. Beyond Repair _____
Some localized erosion with gravel exposed -
Many large trees, mostly oak.

Downstream Face of Dam Condition: 1. Good _____ 2. Minor Repairs _____ *

3. Major Repairs _____ 4. Urgent Repairs _____

Comments: Many large trees

Emergency Spillway: Condition: 1. Good _____ 2. Minor Repairs _____ *

3. Major Repairs _____ 4. Urgent Repairs _____

Comments: Some grouting of granite blocks necessary.

No flashboards.

Lower Level of Inspection: 8 inches ft. above _____ * below _____

top of dam _____ principal spillway _____ *

other _____

(11) Summary of Deficiencies Noted:

Grass (Trees and Brush) on Embankment Yes - should be removed

Animal Burrows and Washouts

Damage to slopes or top of dam Some minor erosion

Cracked or Damaged Masonry

Evidence of Seepage

Evidence of Piping

Excavation Localized on upstream face due to foot traffic

Leaks

Wash and/or debris impeding flow

Clogged or blocked spillway

Other

(12) Remarks & Recommendations: (John England)

Growth on earth portion of dam should be controlled.

(13) Overall Condition:

1. Safe * - maintenance necessary
 2. Minor repairs needed _____
 3. Conditionally safe - major repairs needed _____
 4. Unsafe _____
 5. Reservoir impounded no longer usable (explain) _____
- Recommend removal from inspection list _____

August 15, 1973

Board of Selectmen
Town Hall
Amesbury, Massachusetts

RE: Inspection-Dam 95-5-7-4
Amesbury
Lake Gardner Dam

Gentlemen:

On August 11, 1973, an engineer from the Massachusetts Department of Public Works made a visual inspection of the above dam. Our records indicate that the Town of Amesbury is the owner. Will you please notify this office if this information is not current.

The inspection was made in accordance with Chapter 253 of the Massachusetts General Laws, as amended by Chapter 595 of the Acts of 1970 (Dams-Safety Act).

The results of the inspection indicate that this dam is safe; however, as previously noted to you in a letter dated, August 14, 1973, (copy enclosed) serious consideration should be given to the removal of the growth of trees on the embankment of the dam. The risk to life and property downstream is rated as disastrous. No work has been done or regular maintenance program initiated since our last notice.

We, again, call these conditions to your attention before they become serious and expensive to correct. If we may be of assistance, please do not hesitate to contact us. With any correspondence, please include the number of the dam as indicated above.

Very truly yours,

ROBERT F. TIMMONS, P.E.
Chief Engineer

RAH:jap
Enc.
cc: Amesbury Cons. Comm.
Chairman Eidelman
Donald Morgan

DISPOSITION REPORT - DMS AND REMEDIALS

(1) Location: Wet/Down Amesbury Section 5-5-2-4
 Name of Dam Lake Gardiner Suspected by: D. P. Morgan, P.E.
 Date of Inspection Aug. 11, 1975

(2) Dam/s: Asesbury Prev. Inspection _____
 Reg. of Dam Asesbury Prev. Control X

1. Town of Amesbury, Amesbury Town Hall
 Name Asesbury St. & No. _____ City/Town _____ State _____ Tel. No. _____
 2. _____
 Name _____ St. & No. _____ City/Town _____ State _____ Tel. No. _____
 3. _____
 Name _____ St. & No. _____ City/Town _____ State _____ Tel. No. _____

(3) Dam/s (if any) e.g. independent, plant, etc. operated by private owner, operated by public owner.

Amesbury DPM
 Name Asesbury St. & No. _____ City/Town _____ State _____ Tel. No. _____

(4) No. of Pictures taken None

(5) Degree of Hazard (if dam should fail completely)*

1. Heavy _____ 2. Moderate _____
 3. Severe _____ 4. Stable X

* This rating may change as land use changes (floods, etc.)

(6) Control Structure: Automatic _____ Manual X

Operating X

Inspection: _____

(7) Remarks: _____

Many large trees (oak, maple, ash) should be removed
 (root systems could lead to piping & windfalls could
 cause breaching) Also minor soil erosion.

DAM NO. 5-5-7-4

(3) Downstream Face of Dam: Condition: 1. Good _____ 2. Minor Repairs _____
3. Major Repairs X 4. Urgent Repairs _____

Comments: Dam is covered with many large oaks, maples & ash trees.
Some minor erosion

(3) Emergency Spillway: Condition: 1. Good _____ 2. Minor Repairs X
3. Major Repairs _____ 4. Urgent Repairs _____

Comments: Some grouting of Granite Blocks would act as preventive
maintenance.

(3) Water Level & time of inspection: 1-Inch ft. Water X Below
top of dam potential spillway X
other _____

(11) Summary of Deficiencies Noted:

Growth (Grass and Brush) on Foundation Dangerously severe

Animal Runways and Washouts _____

Damage to slopes or top of dam Minor erosion

Cracked or Damaged Masonry _____

Seepage of Seepage _____

Exposure of Piping _____

Erosion Minor

Leaks _____

Unusual or Excessive Vibrations _____

Unusual or Excessive Noise _____

12. Remarks & Recommendations: (Fully Explain)

Growth noted at last inspection has not been removed
and presents a potential hazard.

13. General Condition:

1. Date _____
2. Major repairs needed X _____
3. Estimate only life - major repairs _____
4. Remarks _____
5. Date _____



The Commonwealth of Massachusetts
Department of Public Works

DISTRICT #5 OFFICE
485 MAPLE STREET, DANVERS

DEPARTMENT OF
ENVIRONMENTAL QUALITY ENGINEERING
DIVISION OF WATERWAYS

Projects - Amesbury

Dam Inspection

July 5, 1977

RECEIVED JUL 8 1977

John J. Hannon, P.E.
Chief Engineer
Division of Waterways, D.E.Q.E.

Referred To _____
Record back to _____
File _____

Attention: Alvin McCallum, Dam Engineer

Dear Mr. Hannon:

Enclosed is a copy of an inspection report of Dam No. 5-5-7-4 at Lake Gardiner in Amesbury, owned by the town of Amesbury.

The inspection was made by Donald P. Horgan, P.E. of this office, John Ward, Director, Amesbury Public Works Department, and Al LaVally, Supervisor, Amesbury Public Works Department.

Mr. Ward has assured Mr. Horgan that maintenance work will begin immediately on this dam.

Very truly yours,

Sherman Eidelman
District Highway Engineer

D.P.H./ t.m.t.

Enclosure

(1) Letter to Deputy Mayor, Amesbury dated 5-5-74
 From: Jack Lake Gardiner D.P. Horgan, P.E.
 Date: July 1, 1977

(2) Country of origin: _____ Port of destination: _____
 Name of vessel: _____ Date of departure: _____

- | No. | Name | Room No. | Salary | Grade | Term |
|-----|--|----------|--------|-------|------|
| 1. | Town of Amesbury, Town Hall, Amesbury, Mass. | | | | |
| 2. | | | | | |
| 3. | | | | | |

(3) Carman, J. W., Jr., Superintendent, Plant No. 1, located at 1000
 Owner, operated by United States
 _____ Amesbury D.P.W., Attn: Al La Valley _____
 _____ _____

(4) No. of Phones Pales None

(5) Degree of Hazard (1-5) (1=low hazard, 5=high hazard)

1. Name _____ 2. Address _____
3. School _____ 4. Birthdate _____

2. This rating may change as I get the chance. (Please do not respond)

(b) Contact: _____ Name: _____
Occupation: _____

(7)

X

Many large trees (Oak, Maple, and Ash) should be removed
(root systems could lead to piping and wind wind falls could
cause breaching).

(8) Summary of Dam Condition: 1. Good _____ 2. Minor Repairs _____
3. Major Repairs _____ 4. Urgent Repairs X
Comments: Dam is covered with many large trees

(9) Emergency Spillway: Condition: 1. Good X 2. Minor Repairs _____
3. Major Repairs _____ 4. Urgent Repairs _____
Comments: _____

(10) Water Level at time of inspection: 1 inch _____ above _____ below _____
top of dam _____ principal spillway _____
other _____

(11) Summary of Deficiencies Noted:
Growth (Weeds and Brush) on Embankment Severe _____
Animal Burrows and Washouts _____
Damage to slopes or top of dam Minor due to foot traffic _____
Cracked or Damaged Masonry _____
Evidence of Seepage _____
Evidence of Erosion _____
Erosion Minor _____
Leaks _____
Trash and/or debris impeding flow _____
Clogged or blocked spillway _____
Other _____

5-5-7-4

(11) Overall Condition: (Fully Satisfactory)

Growth noticed at inspections in 1973 and 1975 has not been removed and presents a potential hazard. John Ward, new director of Amesbury D.P.W. has assured Mr. Morgan of this office that clearing will begin immediately.

(12) Overall Condition:

- A. Safe
- B. Minor repairs needed, ☒
- C. Conditionally safe - major repairs needed
- D. Unsafe
- E. Destroyed or abandoned

AMESBURY

DESCRIPTION OF DAM

DISTRICT 5

Submitted by Donald P. Morgan

Dam No. 5-5-7-4

(1.) Location: Topo Sheet No. 36 C

Provide $2\frac{1}{2}'' \times 11''$ in clear copy of topo map with location of Dam clearly indicated.

678,000 : 750,300

(2.) Year built: 1872 Year/s of subsequent repairs: 1929

(3.) Purpose of Dam: Water Supply X Recreational X
Irrigation _____ Other _____

(4.) Drainage Area 50 ± sq. mi. acres

(5.) Natural Ponding Area: 1100 ± Acres; Ave. Depth _____
Impoundment: _____ gals; _____ acre ft.

(6.) No. and type of dwellings located adjacent to pond or reservoir _____
i.e. summer homes etc., 10⁺ dwelling houses; Apartment complex

(7.) Dimensions of Dam: Length 350 Ft. Max. Height 21 Ft.
Slopes: Upstream Face _____
Downstream Face _____
Width across top 9 to 12 Ft.

(8.) Classification of Dam by Material:

Earth * Comp. Masonry _____ Stone Masonry _____
Timber _____ Rockfill _____ Other _____

(9.) 1. Doest dam or project have any downstream of _____ ft. 100 ft.
2. Is there a storage area or flood plain downstream of dam which could accommodate the
impoundment in the event of a complete dam failure? yes _____ no _____

DAM NO. 5-5-7-4

Risk to life and property in event of complete failure.

No. of people 100 ±

No. of houses 50 ±

No. of businesses 10 ±

No. of industries 5

Type Mills

No. of utilities 4

Type Water, gas, electric, sewer

Railroads

Other dams 1

Other Bridges - 4

Attach Sketch of dam to this form showing section and plan on 8½" x 11" sheet.

see attached 1929 repair plan.

STATE OF MASSACHUSETTS
DEPARTMENT OF PUBLIC WORKS



OF: Proj. Mgt. Branch - Mr. Gould

NEDEC-7

Dam Safety Assessment and Meeting with Local
Officials, Lake Gardner, Amesbury, MA

Chief, Engineering Division

Chief, F&M Branch

5th
26 May 1978
Mr. Hart/dc/365

1. Summary. Lake Gardner is located about 1,000 feet upstream of the center of Amesbury, MA. The dam retains Lake Gardner which is a source of water for recreation. The dam consists of an uncontrolled granite block spillway with adjacent earth embankments. The overall length of dam is about 350 feet and the maximum height is about 25 feet. Portions of the upstream slope of the west earth embankment (right side) have been severely eroded by wave action. A portion of the downstream toe adjacent to the west spillway wingwall has been eroded by the spillway tailwater. Seepage emergence was observed on the downstream slope about 15 feet below crest of dam over a length of about 50 feet. Some woodchuck holes were also observed on the downstream slope. The dam does not appear to be in imminent danger of failing; but remedial actions of temporary emergency and permanent types must be taken in the near future. This dam is now being assessed by Haley and Aldrich, Consulting Engineers, under the National Dam Safety Inspection Program.

2. Place and Date. Lake Gardner Dam on the Powwow River, Amesbury, MA on 23 and 24 May 1978.

3. Purpose. To provide technical assistance in evaluating the condition of the dam in response to a report of critical situation relative to the safety of the dam.

4. Attendance.

23 May 1978	-	Mr. Bob Gonthier - Chairman, Board of Selectmen
		Mr. George Pace - DFW
		Mr. John Hart - Engrg. Div., F&M Branch
		Mr. Rudy Chlanda - "
24 May 1978	-	Representatives - Town of Amesbury
		Representatives - Haley & Aldrich, Consultants
		Mr. Mike Piacello - Dept. of Waterways, State of Mass.
		Mr. John Hart - Engrg. Div., F&M Branch
		Mr. Rudy Chlanda - "
		Mr. George Laraway - Engrg. Div., WCB

5. Conclusions and Recommendations.

a. The dam is located immediately upstream of the center of Amesbury; consequently, a failure could have serious consequences from the standpoint of loss of life and damage to property.

DEED-7

3
15 May 1978

SUBJECT: Dam Safety Assessment and Meeting with Local Officials, Lake
Gardner, Amesbury, MA

b. With a flood pool at top of dam, the spillway capacity is about 7,000 cfs or 150 csm. The spillway is considered of adequate size to pass a major flood. Refer to Inclosure 2 - Spillway Rating Curve.

c. At the present time, the embankments and spillway appear to be stable and there is no evidence that they are in imminent danger of failure or collapse.

d. Portions of the upstream slope of the west earth embankment have been severely eroded by wave action. Continued erosion by wave action could eventually breach the crest of the dam and lead to overtopping of the embankment during a major flood. Emergency type remedial work on the more severely eroded areas should be initiated by the town before the arrival of the hurricane season. This work should consist of restoration of the slopes and the provision of slope protection in eroded areas.

e. Permanent type repairs to the upstream slope should include removing all the tree stumps and as much of the root system as possible, reconstruction of the slope to its original configuration, and provision of slope protection.

f. Seepage has been emerging on the downstream slope of the west embankment for many years. This seepage is more visible now that the heavy growth of trees has been removed. No evidence of piping or erosion channels was observed.

g. At the present time, there is no danger of failure of embankment by subsurface erosion. The seepage emergence area on the downstream slope should be continually observed, particularly during periods of high water (above El. 93). This area should be inspected about once a week and immediately after the lake is raised. This office (Corps of Engineers) should be notified immediately if seepage quantities substantially increase or movement of soil particles from the embankment is observed.

h. The lake level should not be allowed to rise above spillway crest elevation except during a major storm.

i. This dam is now being examined by a consultant (Haley & Aldrich) hired by the Corps under the Dam Safety Inspection Program.

7. Narrative.

a. The Lake Gardner Dam is located on the Powwow River and controls the level of Lake Gardner. The dam is located about 2,000 feet upstream of the center of the town of Amesbury and is owned by the town. The dam was originally constructed about 1873 to supply water for a mill located just downstream of the dam. The dam was later raised about 3 feet in 1929 to provide additional protection against overtopping. The dam now retains Lake Gardner which is a source of water for recreation. Refer to Incl. 1 - Quad. Sheet.

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50
24 May 1978

SUBJECT: Dam Safety Assessment and Meeting with Local Officials, Lake
Gardner, Amesbury, MA

b. The dam consists of an uncontrolled granite block spillway, an adjacent penstock and is abutted on both sides by earth embankments. The overall length of the dam is about 900 feet. The embankment on the east side (left bank) is about 100 feet in length while the west side embankment is about 700 feet in length. The west side embankment averages about 20 feet in height with a maximum of about 25 feet adjacent to the spillway. Prior to the fall of 1977, the slopes of the west embankment were covered with a heavy growth of trees. The trees have all been cut recently by the town which is now in the process of removing the trunks from the embankment. Refer to Incl. 3 - Cross Sections

c. Town and state officials reported that the dam was maintained throughout its existence especially with respect to the upstream slope until 10 years ago. The dam has not received good maintenance since its purchase by the town about 10 years ago. ~~The penstock has been filled with concrete and the only present means of draining the lake is through a 24-inch gated pipe.~~ Because of the low capacity of this pipe, the lake can only be drained during the low flow summer months.

d. At the time of inspection, 4-foot of water was flowing over the spillway. The lake level was 7.5 feet below top of the earth embankment. Town officials reported that the lake seldom rises much above this level - even after heavy rains.

e. Portions of the upstream slope of the west side earth embankment have been severely eroded by wave action. In two areas, embankment erosion (about 6 foot wide) has progressed back to the upstream side of the crest. Remedial work should include the removal of the stumps and portions of the root system and then filling the resulting excavated and eroded areas with earth fill protected by stone protection.

f. A portion of the downstream toe (west embankment) adjacent to the granite block wingwall has been eroded by turbulence of the tailwater. This area measures about 20 feet long by 10 feet wide. This area should be filled with a pervious bony gravel protected by stone protection material.

g. Seepage emergence was observed on the downstream slope about 15 feet (measured vertical) below the dam crest and about 5 feet above the toe. This seepage area is about 50 feet long and is located about 150 feet west from the spillway wall. The existing velocities are extremely low and there is no evidence of particle movement. No evidence of piping or erosion channels were observed. Three woodchuck holes were observed in this area above the saturation line. No water was flowing from these holes nor was there any evidence of water in these holes.

NEED-F

34

25 May 1978

SUBJECT: Dam Safety Assessment and Meeting with Local Officials, Lake
Gardner, Amesbury, MA

h. Excavations (with shovel) along the upstream slope of the dam indicate that the embankment materials are predominantly gravelly silty sands (SM). These soils are considered semi-impervious to impervious. Some areas on the upstream slope contain clean pervious sands and gravels which were probably dumped into eroded areas during past maintenance operations.

Incls
as

TIERSON

CF
Proj. Mgt. Br. (Mr. Gould)
F&M Br Files
Eng Div Files

30 May 1978
File No. 416014

Department of the Army
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, MA 02154

Attention: Mr. Joe B. Fryar, Chief Engineer

Subject: Lake Gardner Dam, Amesbury, MA
Contract No. DACW-33-78-C-0301

Gentlemen:

On 24 May 1978, Mr. Peter L. LeCount and Mr. John W. Critchfield of this office attended an on-site meeting at Lake Gardner Dam in Amesbury, Massachusetts. Also present were representatives of the Corps of Engineers, the Massachusetts Department of Environmental Quality Engineering, the Amesbury Department of Public Works and Camp, Dresser & McKee, Inc. (as a consultant to Haley & Aldrich, Inc.).

The purpose of the meeting was to make an evaluation of the westerly earth embankment in response to concerns voiced by Mr. William Day, Consultant in Geotechnical Engineering, of Newton Centre, Massachusetts. Specifically, Mr. Day's correspondence has expressed his concern that upstream erosional features and downstream toe seepage, which he had observed, were indications of serious instability in the earth embankment and impending breaching of the dam.

This letter is intended to 1) summarize visual observations of the embankment that were made by Haley & Aldrich, Inc. on 24 May 1978, 2) state our initial conclusions regarding the stability of the west embankment, based on the visual observations, and 3) present our recommendations with regard to further action that should be taken at this time. We have not as yet made a complete inspection of the dam.

The attached sketch summarizes our field observations along the earth embankment. A baseline was established along the crest by Haley & Aldrich

30 May 1978

for reference in recording observations. Significant points regarding these observations are noted below:

1. Upstream erosion varied, but was quite extensive in some places, and is apparently the result of wave action in combination with foot traffic over some period of time. It has been reported in past inspections by the State, and has probably become much more evident since the recent cutting of trees on the embankments.
2. Seepage was observed on the downstream slope within the general area noted on the sketch. This area was generally wet and soft. Substantially clear water was observed to be flowing slightly in this zone and in the area below the toe. Occasional fine particles could be seen locally in the flow, and some patches of light colored fine sand and silt were observed in depressions on the slope. However, no accumulations of fines that would indicate active piping were noted.
3. Large stumps on the embankment do not yet appear to be deteriorated and do not seem at this time to be significant with regard to embankment stability.

It is our opinion that the erosional and seepage features observed are not cause for immediate concern. However, the condition of the embankment should be regularly monitored for the next few months, until, in the course of the scheduled Phase I Evaluation for this dam, a plan for further study or remedial action can be developed. We would expect that repair of the upstream face of the embankment should be accomplished in the not-too-distant future. Whether or not there should be specific remedial measures with respect to seepage has not yet been determined.

We recommend that the condition of the embankment be checked weekly during June, with frequency thereafter to depend on the conditions that have been observed. Particular attention should be given to the position and appearance of the seepage zone on the downstream slope and the level of the lake at the time of each visit.

We will await your authorization before proceeding with further inspection at the Lake Gardner Dam.

Please contact us if you have questions, or if you need further information.

Sincerely yours,
HALEY & ALDRICH, INC.

John W. Critchfield

AL
Peter L. LeCount
JWC/PLL/mc
Enclosure

APPENDIX C
SELECTED PHOTOGRAPHS OF PROJECT

LOCATION PLAN

Page No.

Site Plan Sketch

1

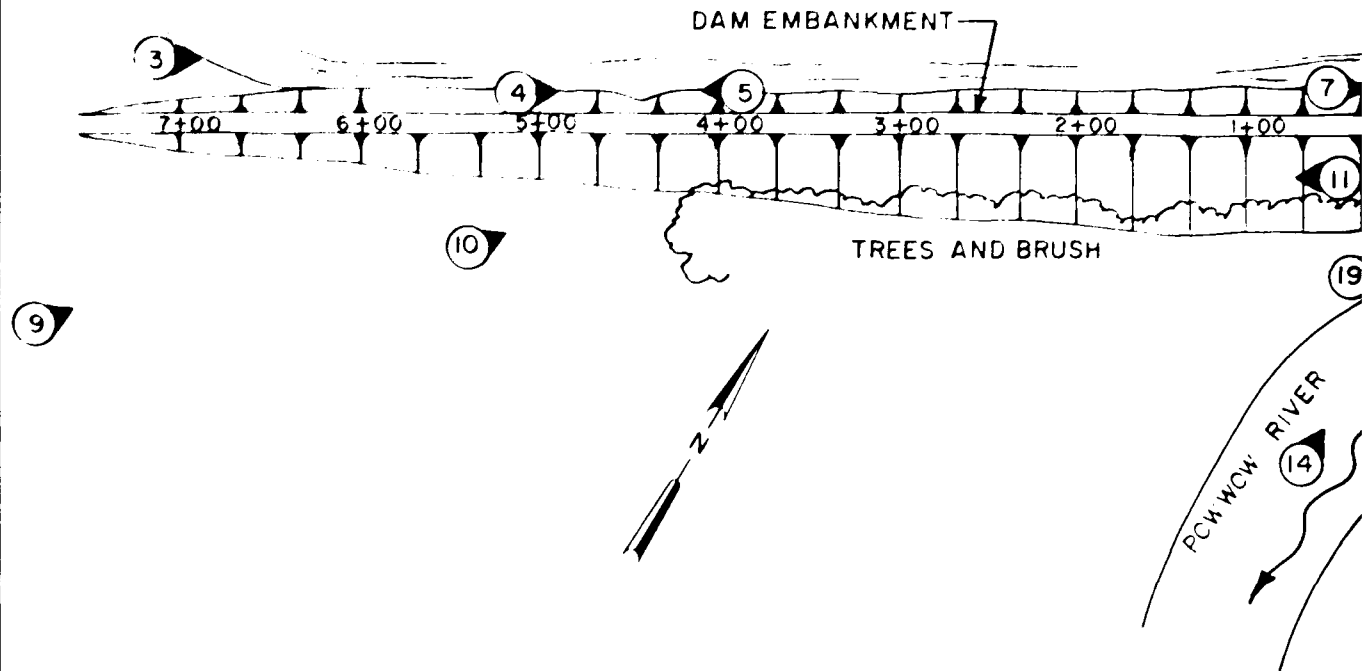
PHOTOGRAPHS

<u>No.</u>	<u>Title</u>	<u>Roll</u>	<u>Frame</u>	<u>Page No.</u>
1.	Overview of Dam Showing Downstream Slope	16	10A	vii, 2
2.	Overview of Dam Showing Upstream Slope	16	9 A	vii, 2
3.	Upstream Slope of Embankment From Right Abutment (Taken on 24 May 1978)	14	22A	3
4.	Upstream Embankment Slope and Crest, Showing Erosion by Wave Action (24 May 1978)	14	16A	3
5.	Upstream Slope Showing Erosion by Wave Action	15	7	4
6.	Upstream Slope Near Spillway	15	3	4
7.	Upstream Slope at Right Side of Spillway	15	9	5
8.	Top of Right Training Wall of Spillway, Upstream End of Wall	15	4	5
9.	Downstream Slope of Embankment, From Right Abutment	16	4A	6
10.	Downstream Slope of Embankment, Near Right End	16	5A	6
11.	Downstream Slope of Embankment, Near Spillway	16	7A	7
12.	Right Training Wall at Spillway and Embankment Slope	16	2A	7
13.	Top of Spillway Showing Embankment Immediately Left of Weir	15	23	8
14.	Spillway Weir and Downstream Slope of Adjacent Embankment	15	15	8
15.	Spillway Weir, Right Side	16	1A	9
16.	Spillway Weir, Left Side	16	3A	9
17.	Granite Masonry at Bottom of Spillway Weir	15	10	10

PHOTOGRAPHS (Continued)

<u>No.</u>	<u>Title</u>	<u>Roll</u>	<u>Frame</u>	<u>Page No.</u>
18.	Contact Between Stone Masonry, Right Training Wall, and Spillway Channel; Seepage Occurs at Base of Wall	C14	18A	10
19.	Abandoned Power House Left of Spillway	15	14	11
20.	Location of Reservoir Drain and Outlet Gates	15	13	11
21.	Outlet Gates, Downstream Side Outlet Gates, Upstream Side	16	0A	12
23.	Channel Immediately Downstream of Spillway	15	22	13
24.	Channel of Powwow River Down- stream of Pond Street	16	12A	13

LAKE GARDNER



NOTE:

PLAN PREPARED FROM 1929 PLAN BY
CHARLES T. MAIN, INC. (APPENDIX B-9)
AND FIELD OBSERVATIONS BY HALEY &
ALDRICH, INC. ON 18 JULY 1978

LEGEND:



PHOTOGRAPH NUMBER AND
DIRECTION OF VIEW

SPILLWAY-

RESERVOIR
DRAIN

PLUGGED -
PENSTOCK

ABANDONED
GENERATOR
HOUSE

FILE NO. 416000 B48

HALEY & ALDRICH, INC
CAMBRIDGE, MASSACHUSETTS

AD-A146 989

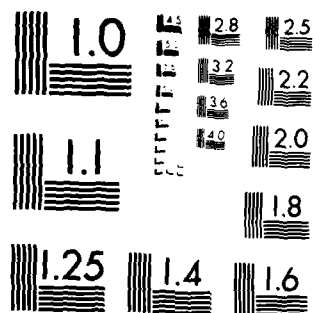
NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
LAKE GARDNER DAM (MA...) CORPS OF ENGINEERS WALTHAM MA
NEW ENGLAND DIV SEP 78

2/2

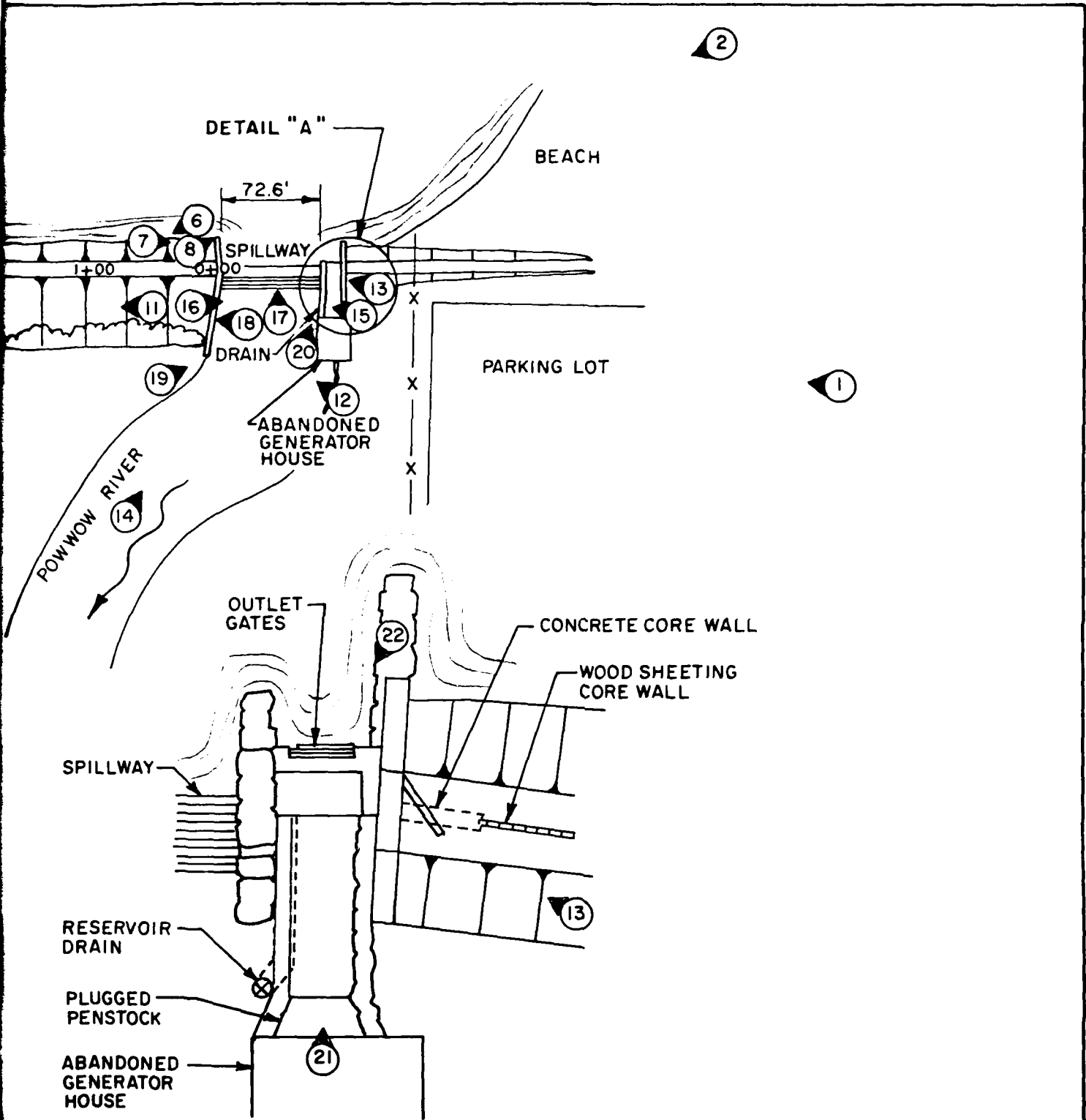
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F/G 13/13 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



LAKE GARDNER DAM
AMESBURY, MASS.

SITE SKETCH PLAN

SCALE: 1" = 100' SEPTEMBER 1978



1. Overview of dam showing downstream slope



2. Overview of dam showing upstream slope



3. Upstream slope of embankment from right abutment
(taken on 24 May 1978)



4. Upstream embankment slope and crest, showing
erosion by wave action (taken on 24 May 1978)



5. Upstream slope showing erosion by wave action



6. Upstream slope near spillway



7. Upstream slope at right side of spillway



8. Top of right training wall of spillway, upstream end of wall



9. Downstream slope of embankment, from right abutment



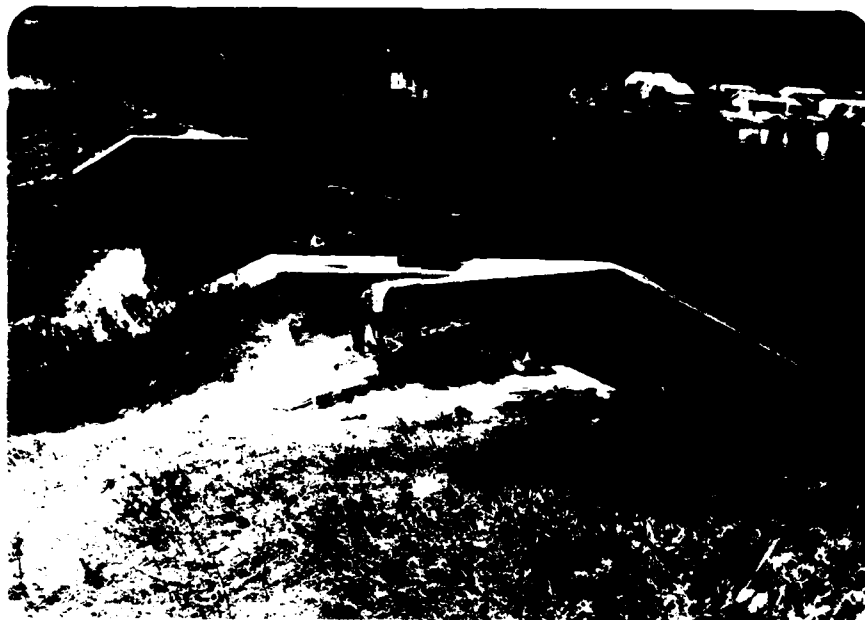
10. Downstream slope of embankment, near right end



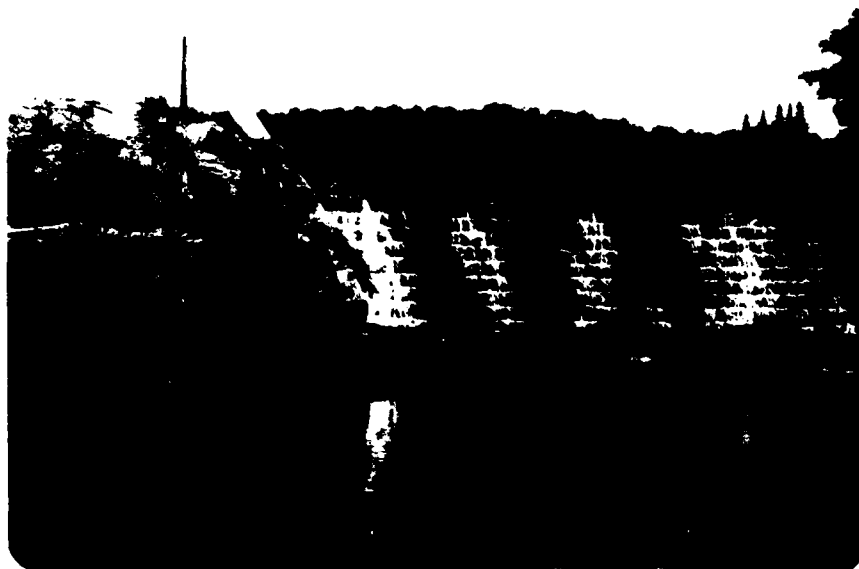
11. Downstream slope of embankment near spillway



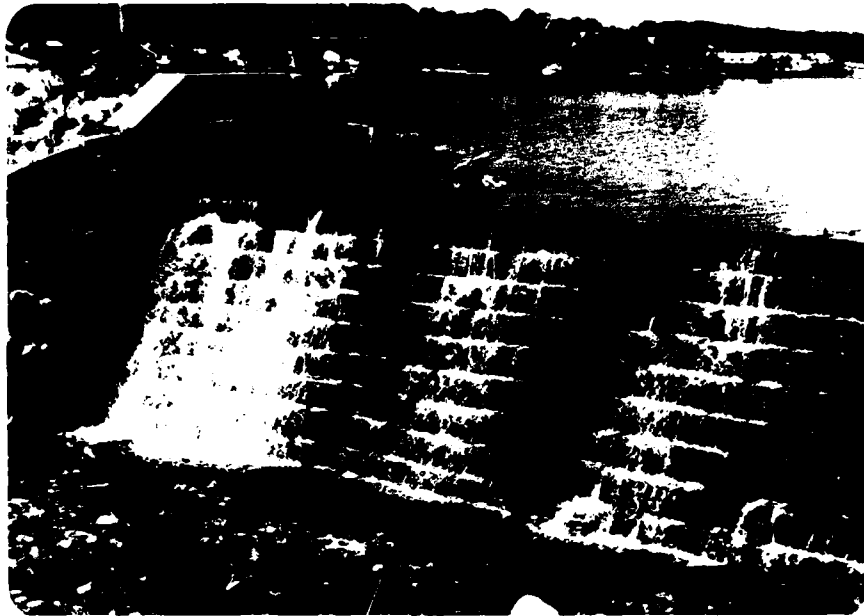
12. Right training wall at spillway and embankment slope.



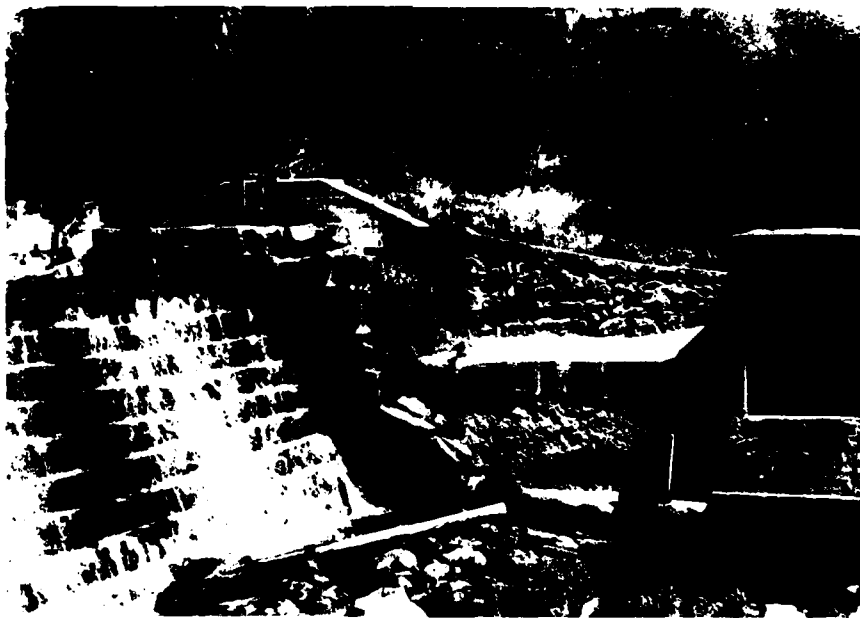
13. Top of spillway showing embankment immediately left of weir



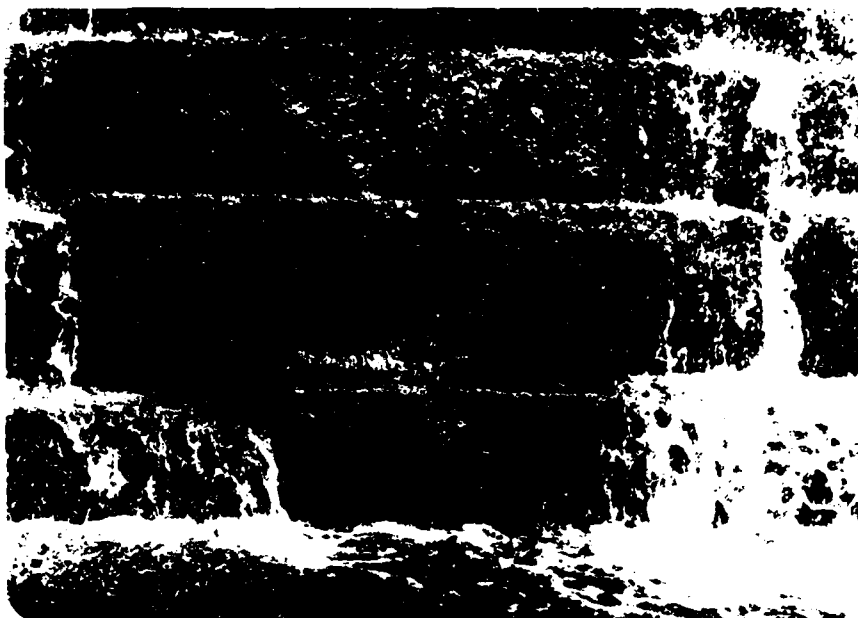
14. Spillway weir and downstream slope of adjacent embankment



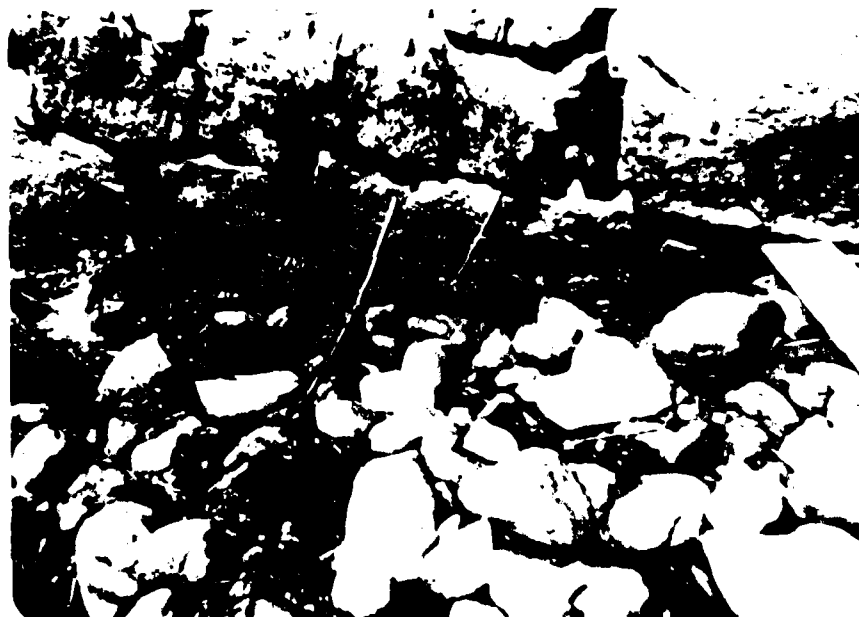
15. Spillway weir, right side



16. Spillway weir, left side



17. Granite masonry at bottom of spillway weir



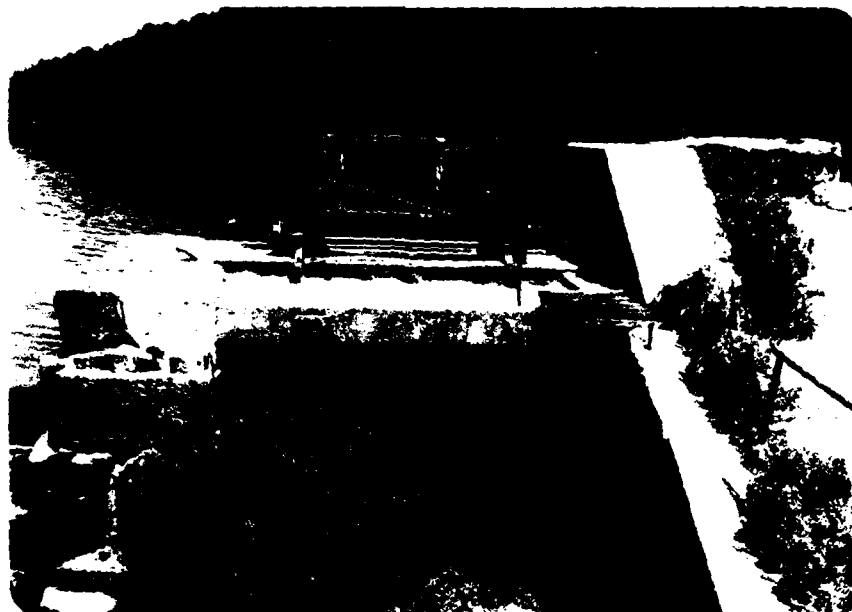
18. Contact between stone masonry, right training wall, and spillway channel; seepage occurs at base of wall



19. Abandoned power house left of spillway



20. Location of reservoir drain and outlet gates



21. Outlet gates, downstream side



22. Outlet gates, upstream side



23. Channel immediately downstream of spillway



24. Channel of Powwow River downstream of Pond Street

APPENDIX D
OUTLINE OF DRAINAGE AREA AND
HYDRAULIC COMPUTATIONS

OUTLINE OF DRAINAGE AREA

Page No.

Drainage Area Map

1

COMPUTATIONS

Size Classification, Hazard Potential Classifica-
tion, Spillway Test Flood, Drainage Area,
Probable Maximum Flood, Historical Floods

2

Spillway Rating Table and Cross Section

3

Spillway Stage-Discharge and Stage-Surface Area
Curves

4

Surcharge Storage Routing

5

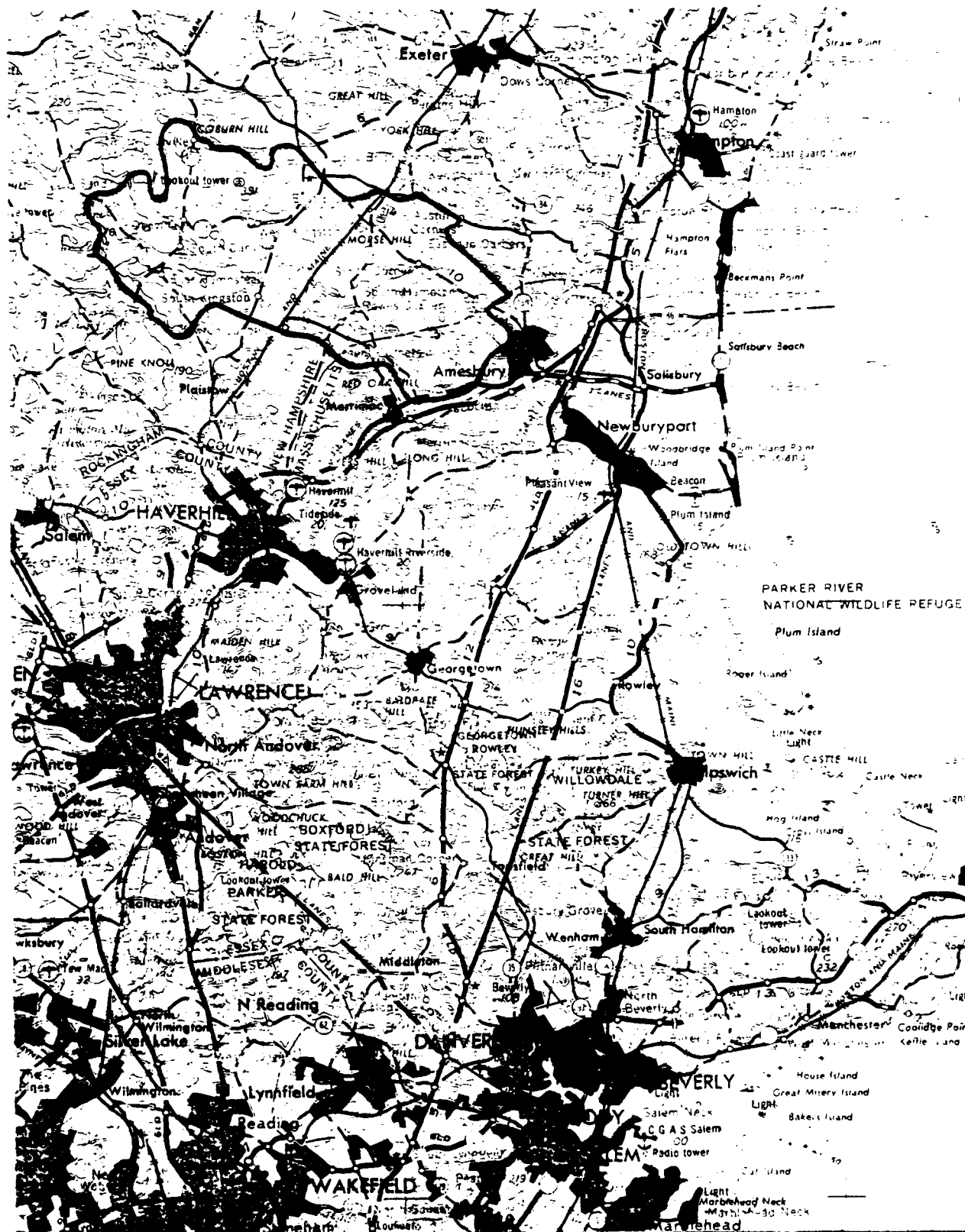
Field Sketch of Lake Attitash and Tuxbury Pond

7

Spillway and Rating Table

Dam Failure Analysis

8



CAMP DRESSER & McKEE Inc.
 Consulting Engineers
 Boston, Mass.



**LAKE GARDNER DAM
 DRAINAGE AREA**

SCALE: 1:250,000

CAMP DRESSER & MCKEE
Environmental Engineers
Boston, Mass.

CLIENT HALEY & ALDRICH
PROJECT NATL DAM INSUR. SRV
DETAIL LACE GARDNER

JOB NO 561-B-RT
DATE CHECKED 9-12-78
CHECKED BY Miller

PAGE 1
DATE 7-17-78
COMPUTED BY ED

SIZE CLASSIFICATION:

* Height = 21 ft. ($< 40\%$)
* Storage > 1000 ac-ft.
* Dam Length is large (550')

INTERMEDIATE

HAZARD POTENTIAL CLASSIFICATION:

Significant downstream development; high economic loss to housing & industry should dam failure occur.

$\therefore$ Category is HIGH

TEST FLOOD:

Hazard HIGH & Size INTERMEDIATE $\rightarrow$ TEST FLOOD = PMF

DRAINAGE AREA:

From Historical Records: about 50 sq. mi.

From inhouse computation: 50.25 sq. mi.

MAXIMUM PROBABLE FLOOD:

Terrain is flat-coastal; watershed concave or approx. 12% lakes & ponds which are uniformly spread throughout the watershed. $\therefore$ use min. csm of 320*

$$\therefore \text{PMF (inflow)} = 320 \text{ csm} \times 50.25 \text{ mi}^2 = 16,280 \text{ cfs} \quad \text{or } 16,000 \text{ cfs}$$

HISTORICAL FLOODS:

1- None recorded

2- FROM HUD - FLOOD INSURANCE STUDY BY CCE (Preliminary)

10YR	550	cfs
50YR	1400	cfs
100YR	1700	cfs
500YR	3300	cfs

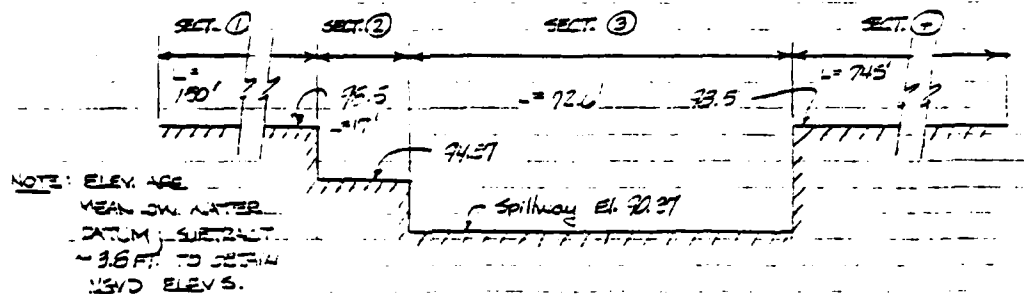
* Auxiliary curve through Points 2, 3, & 5 felt to be more representative

CAMP DRESSER & MCKEE
Environmental Engineers
Boston, Mass.

CLIENT HALEY & ALDRICH
PROJECT NAT'L DAM EMER
DETAIL LAKE GARDNER

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DATE CHECKED 9-18-78
CHECKED BY Miller

PAGE 2
DATE 7-17-78
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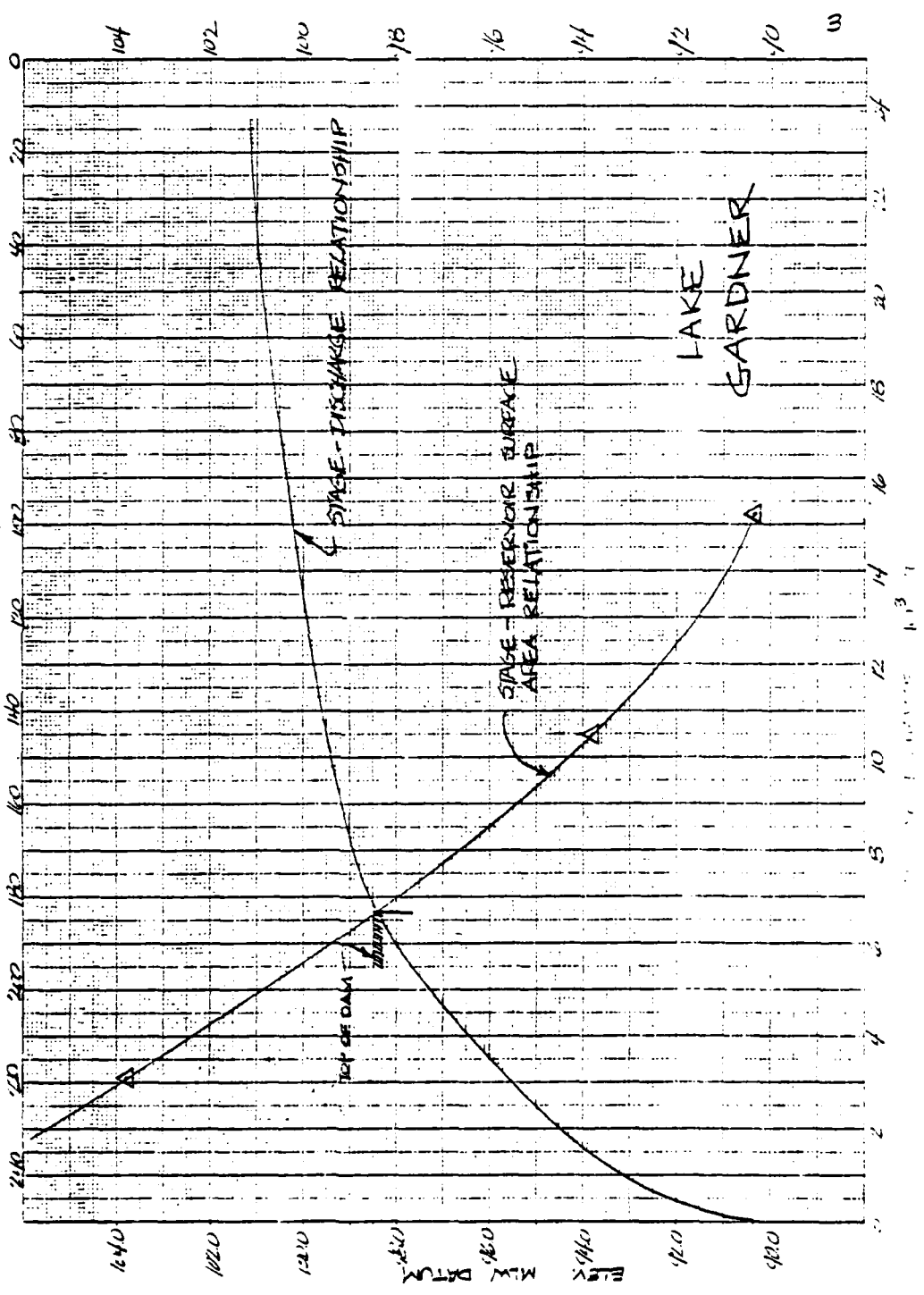
W.S. EL. (MLW)	SECTIONS ① & ④ L = 100' + 74.5 = 895	SECTION ② L = 17	SECTION ③ L = 72.6	TOTAL Q (CFS)
70.97	-	-	0	0
70.50	-	-	$Q_3 = 2.9 (72.6) (1.3)^{1.5}$ = 10	10
71.0	-	-	$Q_3 = 2.9 (72.6) (1.3)^{1.5}$ = 105	105
72.0	-	-	$Q_3 = 2.9 (72.6) (1.3)^{1.5}$ = 277	277
74.57	-	0	$Q_3 = 3.35 (72.6) (1.3)^{1.5}$ = 209	209
75.0	-	$Q_2 = 2.6 (17) (1.43)^{1.5}$ = 12	$Q_3 = 3.4 (72.6) (1.3)^{1.5}$ = 245	257
76.0	-	$Q_2 = 2.6 (17) (1.43)^{1.5}$ = 76	$Q_3 = 3.55 (72.6) (1.3)^{1.5}$ = 344	351
76.5	-	$Q_2 = 2.6 (17) (1.43)^{1.5}$ = 285	$Q_3 = 3.70 (72.6) (1.3)^{1.5}$ = 361	394
76.5	0	$Q_2 = 2.65 (17) (1.43)^{1.5}$ = 351	$Q_3 = 3.75 (72.6) (1.3)^{1.5}$ = 371	402
79.0	$Q_{1+4} = 2.48 (895) (1.5)^{1.5}$ = 848	$Q_2 = 2.6 (17) (1.43)^{1.5}$ = 722	$Q_3 = 3.8 (72.6) (1.3)^{1.5}$ = 379	324
100.0	$Q_{1+4} = 2.93 (895) (1.5)^{1.5}$ = 4518	$Q_2 = 2.67 (17) (1.43)^{1.5}$ = 374	$Q_3 = 3.8 (72.6) (1.3)^{1.5}$ = 379	13636
102.0	$Q_{1+4} = 3.09 (895) (1.5)^{1.5}$ = 18,100	$Q_2 = 2.70 (17) (1.43)^{1.5}$ = 330	$Q_3 = 3.5 (72.6) (1.3)^{1.5}$ = 109	29972
101.0	$Q_{1+4} = 3.05 (895) (1.5)^{1.5}$ = 10,790	$Q_2 = 2.68 (17) (1.43)^{1.5}$ = 743	$Q_3 = 3.8 (72.6) (1.3)^{1.5}$ = 926	21,074

LAKE GARDNER DAM & SPILLWAY

$$\text{Spillway (Sect. 2 \& 3)} \leq \text{PMF Rel. El. 101.3} = [(74.3 + 95.61) - (57.4 + 52.44)] \times 1.3 \\ + (57.4 + 52.44) = 72.4 \text{ cfs}$$

5-16-73
C. Fisher

NOTE: 104.10 TO THE CENTIMETER 40 1012
RESERVOIR SURFACE AREA - A-RES



TRIAL:

I SURCHARGE STORAGE - LAKE GARDNER

1. PEAK INFLOW = $50.25 \text{ sq. mi.} \times 320 \text{ csm} = 16,280 \text{ cfs}$ (PMF)
- 2a. SURCHARGE HEIGHT @ PMF = 100.4
- b. SURCHARGE VOLUME @ PMF = $(974,000 + 97,000) \times 2 \times 100.4 \div 2$
 $= 1,475,000 \text{ cu. ft.}$
 $1,475,000 \text{ cu. ft.} \div 53.3 \times 50.25 \text{ ac} = 0.55 \text{ inches} = \text{STOR}_1$
- c. $Q_{p2} = 16,280 \times (1 - 0.55/1.9) = 15,600 \text{ cfs}$
- 3a. SURCHARGE HEIGHT @ $Q_{p2} = 100.3$
 $\text{STOR}_2 = 0.55 \text{ inches}$
 $\therefore \text{AVG. STOR.} = 0.55"$
- b. Then $Q_{p2} = Q_{p1} = 15,600 \text{ cfs}$

CONCLUSION:

STORAGE REDUCTION MINIMAL - MUST
GO UPSTREAM TO LAKE ATTITASH

II SURCHARGE STORAGE - LAKE ATTITASH AND ADJACENT SWAMPS

TRIBUTARY D.A. TO SPILLWAY CONTROLLING
LAKE ATTITASH AND TUXBURY REND = 47.05 mi^2

THEN INFLOW PMF = $47.05 \text{ mi.}^2 \times 340 \text{ csm} = 16,000 \text{ cfs}$

ROUTE 16,000 cfs THRU LAKE ATTITASH & TUXBURY REND
AND ADD INTERVENING D.A. TO OUTFLOW ($32 \text{ mi}^2 \times$
 $650 \text{ csm} = 2,080 \text{ cfs}$) TO OUTFLOW. (SEE PAGE 6 FOR
 OUTLET)

1. PEAK INFLOW = 16,000 cfs
- 2a. SURCHARGE HT₁ = 106.4
- b. SURCHARGE VOL. @ 16,000 cfs = $(5700 - 4540) \times 3.9 + 4540$
 $= 11,130 \text{ cu. ft.}$
 $11,130 \text{ cu. ft.} \div [53.3 \times 47.05 \text{ ac}] = 5.63 \text{ inches} = \text{STOR}_1$
- c. $Q_{p2} = 16,000 \times (1 - 5.63/1.9) = 11,255 \text{ cfs}$
- 3a. SURCHARGE HT₂ = $(11,255 - 575) \div 3537 = \text{EL. } 105.0$

SURCHARGE VOL. 2 @ 11,255 cfs = $(5700 - 4540) \div 3 \times 3.9 + 4540$
 $= 11,340 \text{ cu. ft.}$
 $11,340 \text{ cu. ft.} \div [53.3 \times 47.05 \text{ ac}] = 4.52 \text{ inches} = \text{STOR}_2$

CAMP DRESSER & MCKEE
Environmental Engineers
Boston, Mass.

CLIENT HALEY & ALDRICH
PROJECT NATL DAM IMP
DETAIL LAKE GARDNER

JOB NO. 2-1-2-R
DATE CHECKED 2-2-78
CHECKED BY BEH

PAGE 5
DATE 2-2-78
COMPUTED BY ED

$$3.0. \quad \text{STCR}_1 + \text{STCR}_2 / 2 = (5.63 + 4.52) / 2 = 5.08 \text{ ft} = \text{STCR AVE}$$

$$\text{THEN } Q_{P2} = 13,553 \left(1 - \frac{5.08}{17} \right) = 11,726 \text{ cfs}$$

$$\text{THEN INFLOW TO LAKE GARDNER} = 11,726 \text{ cfs} \\ + 2,530 \\ \underline{\hspace{1.5cm}} 13,806 \text{ cfs}$$

II. REVISED ROUTING - LAKE GARDNER

1. PEAK INFLOW = 13,806 cfs

2a. SURCHARGE HT. = 100.05

b. SURCHARGE VOL. = 0.55 ft-cfs (FROM PREVIOUS COMPUT.)

c. $Q_{P2} = 13,806 \left(1 - \frac{.53}{19} \right) = 13,423 \text{ cfs}$

2a. SURCHARGE HT. = 99.96

$\text{STCR}_2 = \text{STCR}_1$, $\therefore \text{AVG. STCR} = .53''$ & $Q_{P3} = Q_{P2}$

$$\text{SIM. OUTFLOW} = 13,400 \text{ cfs}$$

FROM STAGE-DISCHARGE CURVE, @ 13,400 cfs
DISCHARGE ELEV. = 100.02

SINCE TOP OF DAM IS AT EL. 101.5' N 1.5' SECT.
OVER DAM

CONCLUS.

EXIST. SPILLWAY IS INADEQUATE
TO PASS THE PMF

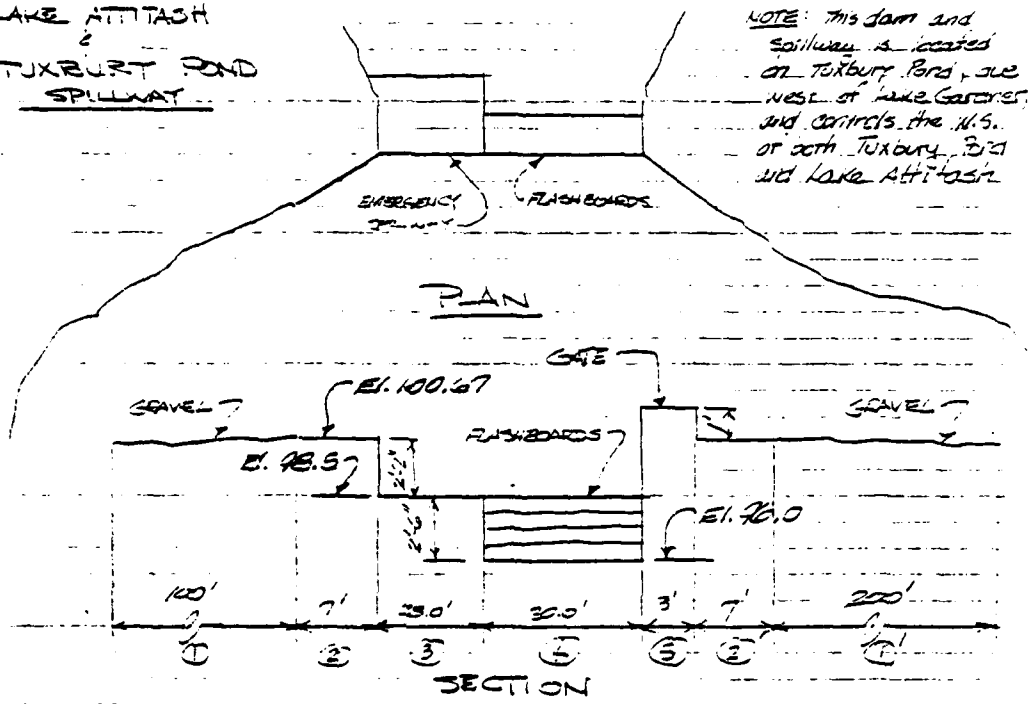
CAMP DRESSER & MCKEE
Environmental Engineers
Boston, Mass.

CLIENT SALEY & ALDRICH
PROJECT NAT'L DAM INCD
DETAIL LAKE GARDNER

JOB NO. EG1-9-07
DATE CHECKED 2-13-79
CHECKED BY Becker

PAGE 6
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LAKE ATTASH
TUXBURY POND
SPILLWAY



NOTE: This dam and spillway is located on Tuxbury Pond, due west of Lake Gardner, and controls the N.E. of both Tuxbury Pond and Lake Attash.

ASSUME FLASHBOARDS ARE REMOVED AND/OR WASHED OUT DURING PMF.
ASSUME SPILLWAY CREST (NO FLASHBOARDS) = ELEV. 96.0 (WELGE ARE ATTASH ON USGS QUAD).

W.S. ELEV.	STORAGE AC-FT.	DEPTH OVER WEIR	SECTION 1	SECTION 2	SECTION 3	SECTION 4	SECTION 5
96.0	1050	0	0	0	0	0	0
100.0	4540	4'	0	0	155	720	0
105.0	11,340	9'	7,642	355	1,392	2,430	50
106.0	13,460	10'	9,517	478	1,725	2,646	75
108.0	16,000	12'	15,384	773	2,460	3,744	133

W.S. ELEV.	TOTAL Q
96.0	0
100.0	875
105.0	11,267
106.0	14,241
108.0	22,491

$$\text{STAGE @ 16,000 cfs: } (22491 - 14641) / 2 = 3925 \text{ cfs/ft.}$$

$$(16000 - 14641) / 3925 = 0.35'$$

$$\therefore 106.0 + 0.35 = \text{ELEV. } 106.4$$

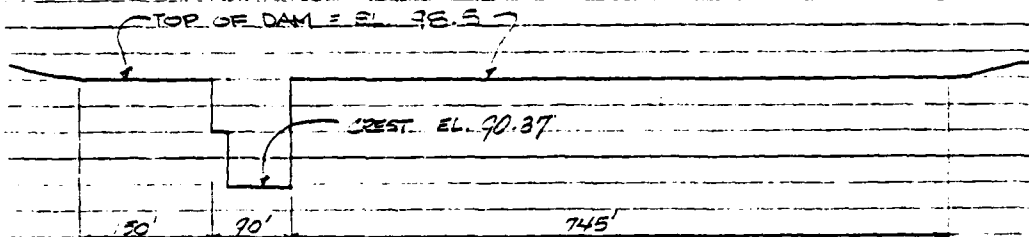
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Environmental Engineers
Boston, Mass.

CLIENT: HALEY & ALDRICH
PROJECT: NAT'L DAM ENSP
DETAIL: LAKE GARDNER

JOB NO. 7.1-B-87
DATE CHECKED: 9-3-78
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DATE 9-7-78
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ESTIMATE PEAK FAILURE OUTFLOW



ASSUME FAILURE OCCURS IN 745' SECTION

THEN $W_b = 745 \times .4 = 300'$

AVG. HT. (Y_0) $\approx 20'$

THEN $Q_p = 9/27 \times 300 \times (32.2)^{1/2} (20)^{3/2} = 45,000 \text{ cfs}$

STORAGE @ W.S. EL. 98.5 = $183 \text{ ac.} \times 20' \times 1/3 = 1,208 \text{ ac.-ft.}$

REACH 1: L. GARDNER TO WOODEN DAM 2/3 OF ROAD ST.

LENGTH = 2100 FT., CREST EL. = 76.7 (from COE FIS Profile)

FROM PRELIMINARY FIS, STAGE-DISCHARGE @ DAM IS

Q (cfs)	550	1400	1800	3500
ELEV.	74.2	75.1	75.4	76.4

(SEE NEXT PAGE FOR FIELD SKETCH OF DAM)

LEFT OVBANK: $L = 80'$, $C = 2.6$

RIGHT OVBANK: $L = 130'$, $C = 2.6$

WEIR: $L = 50'$, $C = 3.8$

DAM: $L = 22.5'$, $C = 3.0$

W.S. ELEV. (USGS)	STORAGE (AC-FT)	DEPTH OVER WEIR	LEFT OVBANK	RIGHT OVBANK	WEIR	DAM	TOTAL FLOW
76.4		5.7	120	510	2,585	240	2,825
80.0	460	9.3	1,355	4,100	5,390	1,130	12,475
85.0	200	14.3	5,700	11,965	10,275	2,550	30,490
90.0	354	19.3	11,250	22,205	16,110	4,545	54,110

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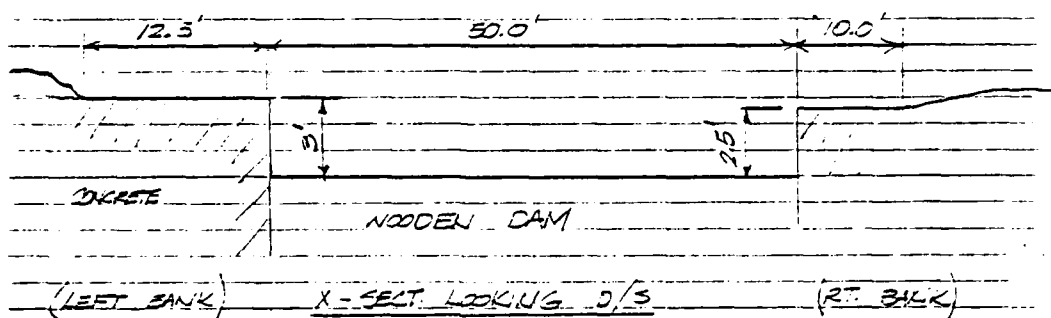
CLIENT HALEY & ALDRICH
PROJECT NAT'L DAM INSP
DETAIL LAKE GARDNER

JOB NO 501-S-RT
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PONNON RIVER D/S OF LAKE GARDNER

WOODEN DAM

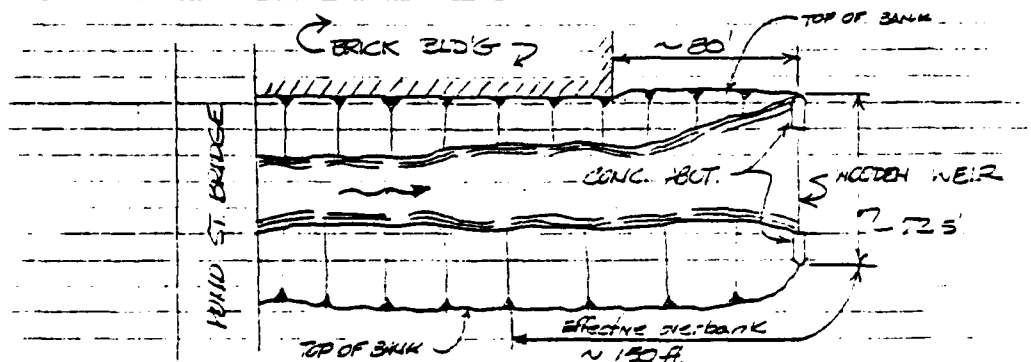


NOTES:

CHANNEL U/S OF DAM IS RESTRICTED ON LEFT BANK BY BRICK BLDG. WHICH EXTENDS ABOUT 2/3 THE DIST. FROM U/S BRIDGE.

GROUND RISES ~2' ON EITHER SIDE OF DAM AND THEN LEVELS OFF FOR SEVERAL HUNDRED FEET.

UPSTREAM BRIDGE IS A MAJOR CONSTRUCTION BUT WOULD PROBABLY BE WASHED OUT IF LAKE GARDNER DAM WERE TO FAIL.



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CLIENT HALEY & ALDRICH
PROJECT NET - DAM ICD
DETAIL LAKE GARDNER

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DOWNSTREAM DAM FAILURE ROUTING

1. $Q_{p1} = 45,000 \text{ cfs}$

2. AT WOODEN DAM: D/S OF ROAD ST.

$Q = 45,000 \text{ cfs}$, $\text{STAGE} = (34,110 - 30,790) / 5 = 4664 / \text{ft}$

$(45,000 - 30,790) / 4664 = 3.05$

THEN $\text{STAGE} = 85.0 + 3.05 = 88.0$

$V = (354 - 200) / 5 \times 3 + 200 = 292 \text{ ac-ft}$

$292 \text{ ac-ft} / 1203 \text{ ac-ft} = 24\% \text{ OF L. GARDNER STORAGE}$

3. $Q_{p2} (\text{TRIP}) = Q_{p1} (1 - \frac{292}{1204}) = 34,100 \text{ cfs}$

A STAGE OF 88.0 AT WOODEN DAM WILL
CAUSE SEVERE FLOODING BETWEEN DAM
AND LAKE GARDNER

DOWNSTREAM OF WOODEN DAM, CHANNEL IS
NARROW AND STEEP (APPROX. $S = 0.070$) WITH
VERY LOW OVBANKS.

APPENDIX E
INFORMATION CONTAINED IN
THE NATIONAL INVENTORY OF DAMS