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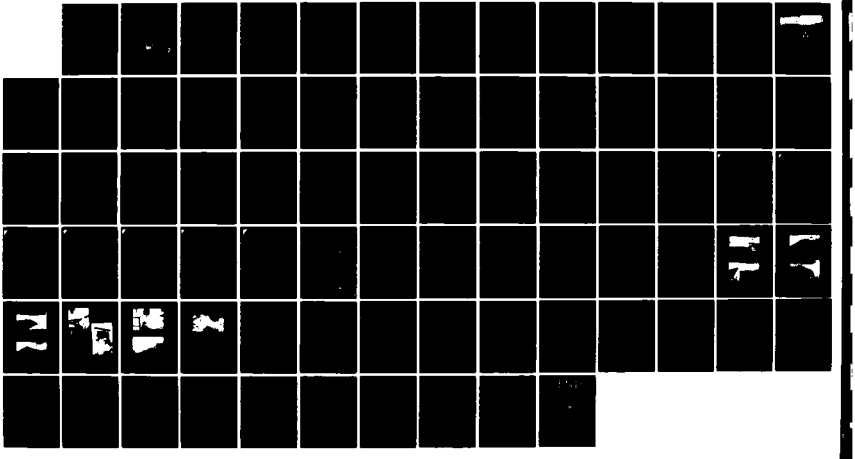

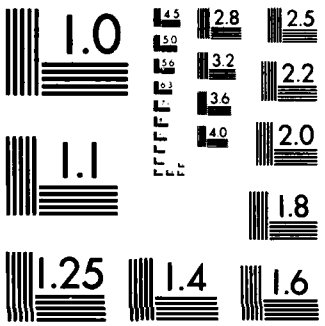

QUINEBAUG RIVER BASIN

SOUTHBRIDGE, MASSACHUSETTS

NO. 5 RESERVOIR
MA 00693

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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

JUNE 1981

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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18. SUPPLEMENTARY NOTES

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

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

DAMS, INSPECTION, DAM SAFETY,

Quinebaug River Basin
Southbridge, Massachusetts
Hatchet Brook- Tributary of the Quinebaug River

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

The dam is an 1130 ft. long, 33 ft. high earth embankment dam. The dam has a classification of small and a hazard potential of significant. There are deficiencies which should be corrected to assure the continued performance of the dam.

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

NEDED

Honorable Edward J. King
Governor of the Commonwealth of
Massachusetts
State House
Boston, Massachusetts 02133

Dear Governor King:

Inclosed is a copy of the No. 5 Reservoir (MA-00693) Phase I Inspection Report, prepared under the National Program for Inspection of Non-Federal Dams. This report is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. I approve the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is vitally important.

Copies of this report have been forwarded to the Department of Environmental Quality Engineering, and to the owner, Southbridge Water Supply Co., Southbridge, MA. Copies will be available to the public in thirty days.

I wish to thank you and the Department of Environmental Quality Engineering for your cooperation in this program.

Sincerely,

C. E. EDGAR, III
Colonel, Corps of Engineers
Commander and Division Engineer

Incl
As stated

A1

NO. 5 RESERVOIR

MA 00693

QUINEBAUG RIVER BASIN
SOUTHBRIDGE, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION
PROGRAM

NATIONAL DAM INSPECTION
PROGRAM

PHASE I INSPECTION REPORT

BRIEF ASSESSMENT

Identification No.: MA 00693

Name of Dam: No. 5 Reservoir

Town: Southbridge

County and State: Worcester County, Massachusetts

Stream: Hatchet Brook - Tributary of the Quinebaug River

Date of Inspection: March 5, 1981

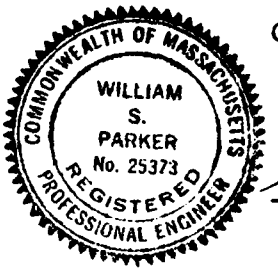
Reservoir No. 5 Dam is an 1130± foot long, 33-foot high earth embankment dam built in 1938 to provide storage and regulate its release as part of the water supply system for the Town of Southbridge, Massachusetts. With the water level at the top of the dam, the storage capacity of the reservoir is 550 acre-feet. The dam is reported to have a concrete masonry core. The outlet works include three 16-inch screened inlets at varying elevations used to provide raw water for a 20-inch water supply outlet, and a 36-inch outlet which discharges at the toe of the downstream slope. Outlets are controlled by valves located in a gatehouse which is just to the right of the center of the dam. The emergency spillway is a 150-foot long concrete broad-crested weir. Flashboards 1.5 feet high can be installed at the spillway. The spillway is located immediately upstream of the right abutment and discharges to a poorly defined natural channel.

The following deficiencies were observed at the site: seepage issuing from the toe of the downstream slope at five (5) separate locations; and minor depressions of the earth embankment behind the rubble wall on the upstream dam face. Generally, the dam is in fair condition.

Based on size classification, small, and hazard potential, significant, the Corps of Engineers Guidelines recommend a test floood range of 100-year frequency to one-half the Probable Maximum Flood. The adopted Spillway Test Flood of one-half the Probable Maximum Flood produced a Peak Test Flood inflow of 1190 cfs. Hydraulic analyses indicate that the emergency spillway, without flashboards, can discharge 3640 cfs and the total routed test flood outflow is 1100 cfs. Thus, the spillway can discharge 330 percent of the routed test flood. The estimated test flood stage is about 2.5 feet below the top of the dam.

It is recommended that the Owner retain a qualified registered professional engineer to investigate the cause and extent of the seepage emanating from the downstream toe of the dam and make appropriate recommendations to alleviate the problem. If the source is identified as the blind stone drains shown on the design plans, then construction of a collector trench as originally proposed would be recommended. If the source of seepage is through the dam embankment or foundation, further studies will be required.

The measures outlined above and in Section 7 should be implemented by the Owner within a period of one year after receipt of this Phase I Inspection Report.



Cullinan Engineering Co., Inc.

William S. Parker, PE
Director of Engineering
Project Manager

This Phase I Inspection Report on No.5 Reservoir (MA-00693) has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice, and is hereby submitted for approval.

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

JOSEPH W. FINEGAN, JR., MEMBER
Water Control Branch
Engineering Division

ARAMAST MAHTESIAN, CHAIRMAN
Geotechnical Engineering Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in Recommended Guidelines for Safety Inspection of Dams, for a Phase I Investigation. 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 investigations, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

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

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

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

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

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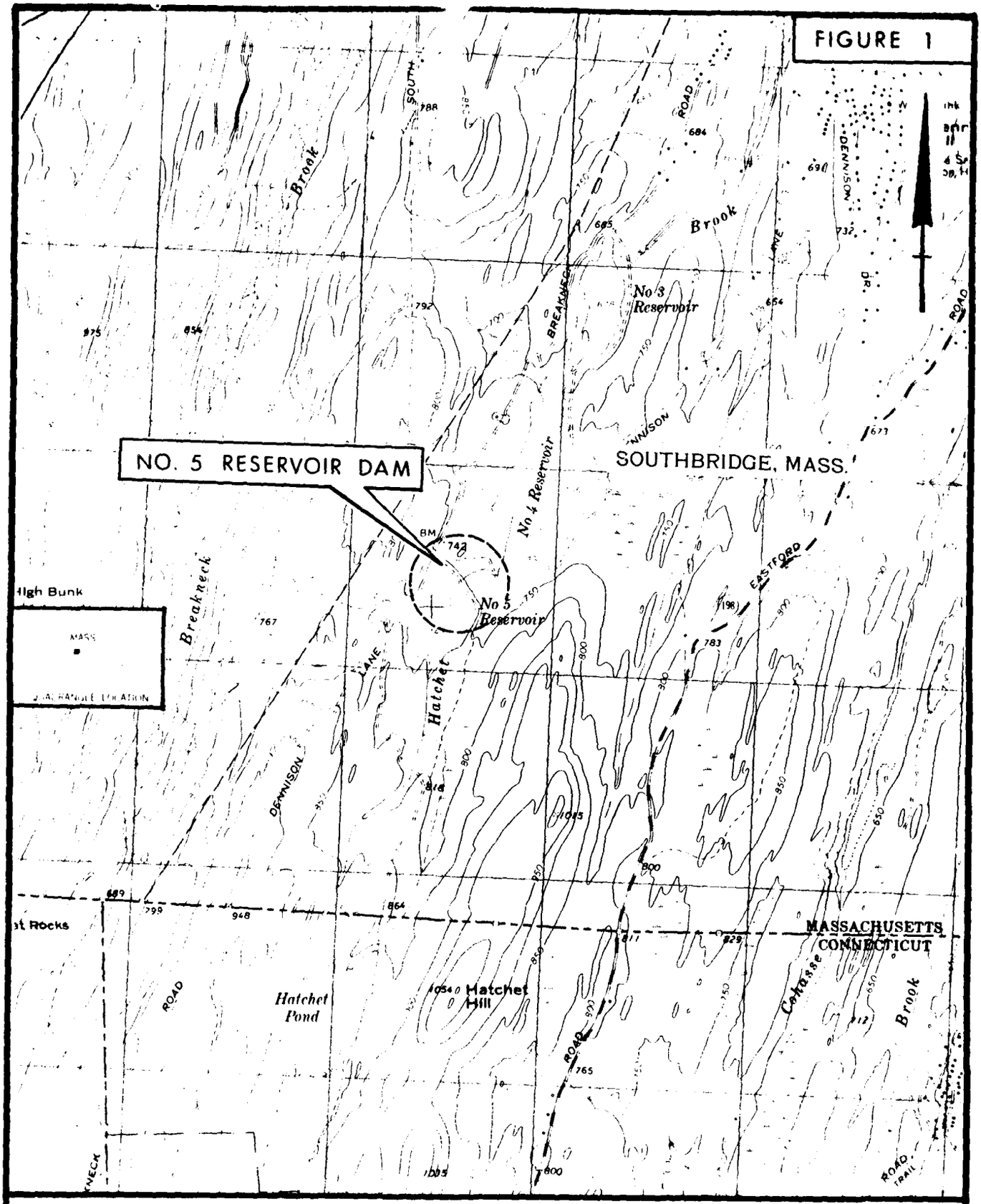
OVERVIEW

U S ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION WALTHAM, MASSACHUSETTS SULLIVAN ENGINEERING CO., INC. CIVIL ENGINEERS AUBURN, BOSTON, MASSACHUSETTS	NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	No. 5 Reservoir Dam Hatchet Brook Southbridge, Mass. MA 00693 March 5, 1981



LOCATION MAP

NO. 5 RESERVOIR DAM
SOUTHBRIDGE , MASS.
1" = 2083'

CULLINAN ENGINEERING CO., INC. SOUTHBRIDGE, MASS, CONN. QUADRANGLE 1979

NATIONAL DAM INSPECTION
PROGRAM

PHASE I INSPECTION REPORT

NO. 5 RESERVOIR

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. Cullinan Engineering Co., Inc., has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Contract No. DACW 33-81-C-0025, dated December 19, 1980, has been assigned by the Corps of Engineers for this work.

(b) Purpose:

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

(2) Encourage and assist the States to initiate quickly effective dam safety programs for non-Federal dams.

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

1.2 DESCRIPTION OF PROJECT

(a) Location. The dam is located on Hatchet Brook, a tributary of the Quinebaug River, in the Town of Southbridge, Worcester County, Massachusetts (see Location Map). Hatchet Brook flows from the dam to Reservoir No. 4 then to Reservoir No. 3, and, finally, to the Quinebaug River in the U.S. Army Corps of Engineers Westville Reservoir Flood Control Impoundment area, a distance of approximately 11,700 feet downstream. The coordinates of the dam are latitude 42 degrees 02.6 minutes north and longitude 72 degrees 04.9 minutes west.

(b) Description of Dam and Appurtenances. Reservoir No. 5 Dam consists of an earth embankment with a concrete core wall, a gatehouse near the center of the dam, and a concrete emergency spillway which discharges into a poorly defined natural channel, at the right abutment.

The embankment is approximately 1130 feet long, has a maximum height of about 33 feet, and is 18 feet wide at the crest. According to the inspection reports and a sketch of the dam obtained from the Division of Waterways and a set of Worcester County Commissioners File Plans for construction, the dam has a concrete corewall and blind stone drains placed at regular intervals in the dam construction. The upstream slope is 2:1 with dumped stone riprap and a 3 foot high dry stone wall at the top of the slope (see Photos No's. 1, 2, and 5) and the downstream slope is 2:1 and grass covered (see Photos No's. 3 and 4).

A gatehouse outlet structure for the dam, is situated just to the right of the center of the dam and is located on the upstream face of the embankment (see Appendix B). The brick gatehouse is built on top of a concrete structure which forms an intake well for the 20-inch water supply line (see Photos No's. 6 and 8). Also included in the structure are three 16-inch diameter water supply inlets which are controlled by handwheel operated sluicegates (see Photo No. 9). The elevations of the inlets are 737.3, 729.8, and 722.3. A 36-inch outlet line is reduced to a 30-inch handwheel operated gate valve within the gatehouse. On the downstream side of the gatehouse, the outlet line is then increased back to its original 36-inch diameter. The 36-inch outlet terminates at a concrete masonry headwall at the beginning of the outlet channel which flows downstream to No. 4 Reservoir. The headwall has 5-foot high concrete wingwalls which extend 10-feet downstream to dry stone wingwalls which are also 10-feet long (see Photos No's. 10 and 11). A 10-foot wide ditch serves as the outlet channel.

At the right abutment is an emergency spillway consisting of a 2-foot wide 150-foot long concrete wall with rod supports for flashboards up to 1.5-feet high (see Photo No. 7). The crest elevation of the weir without flashboards is 744.0. Short dry stone training walls about 4-feet high are at each end of the emergency spillway. Flow from the emergency spillway discharges to a poorly defined channel which has a 6:1 slope. Spillway discharge from No. 5 Reservoir passes downstream to No. 4 Reservoir.

(c) Size Classification. According to the Corps of Engineers' Recommended Guidelines for Safety Inspection of Dams, a dam is classified as "small" in size if the height is between 25 feet and 40 feet, or the dam impounds between 50 Acre-Feet and 1,000 Acre-Feet. The maximum height of the dam is approximately 33 feet and the estimated total storage capacity at the top of the dam is 550 Acre-Feet. Thus, the dam is classified in the "small" category based on both height and storage capacity.

(d) Hazard Classification. The results of the dam failure analysis indicated that downstream Reservoir No. 4 and Reservoir No. 3 would be overtopped by approximately 3.7 feet and 1.7 feet, respectively, as a result of the failure outflow. Neither of these areas would be overtopped prior to failure of the dam at No 5 Reservoir. The flow would continue downstream (approximately 12,000 feet from No. 5 Reservoir) before reaching the Westville Reservoir Flood Control Impoundment area where the failure outflow would be attenuated. Consequently, with the appreciable economic loss that could occur, and the loss of water supply, the dam has been classified in the "significant" hazard category.

(e) Ownership. The dam is owned by the Southbridge Water Supply Co. The owner is represented by Mr. Chester Spielvogel, Superintendent and Treasurer, 70 Foster Street, Southbridge, Massachusetts 01550 (Phone 617/764-3207).

(f) Operator. Mr. Maurice Comtois is assigned responsibility for operation of the dam. His business and home address is Breakneck Road, Southbridge, Massachusetts 01550 (Phone 617/764-8092).

(g) Purpose of the Dam. Reservoir No. 5 Dam provides for water storage and regulates its release as part of the water supply system for the Town of Southbridge, Massachusetts.

(h) Design and Construction History. No. 5 Reservoir Dam was designed by Fay, Spofford, and Thorndike of Boston, Massachusetts. The contract drawings were filed at the Worcester County Commissioners Office in 1936 with the actual construction of the dam completed in 1938. Inspection indicates that the dam was constructed essentially as shown on the 1936 plans filed with the Worcester County Commissioner except that the interceptor ditch for the blind stone drains at the downstream toe of the embankment was not constructed.

(i) Normal Operating Procedures. Under normal conditions, only one of the 16-inch intake lines (usually the highest) is open. Water then flows into a 20-inch supply line at the gatehouse. From the gatehouse the 20-inch supply line flows cross country to No. 4 Reservoir where it is reduced to a 16-inch pipe and is cross connected to a 16-inch supply pipe from No. 4 Reservoir. The common 16-inch supply line then ties into the Town of Southbridge water supply system at Dennison Crossroads.

The 36-inch outlet is opened only to drain the reservoir or it could be used during periods of high flow. However, it is reported by the Town of Southbridge Water Department that is has not been necessary to operate the valve for high flow conditions as the water level in the reservoir has never been more than 6 inches over the emergency spillway crest. Generally, the outlet valve is checked every two years to insure its operability. Flashboards are usually left in place over 50 to 60 percent of the emergency spillway length. Daily checks on the reservoir level are made by the operator who also periodically cleans the screens on the intake lines and operates the valves, to make sure they are functioning.

1.3 PERTINENT DATA

Elevations referred to in this report were taken from the construction plans obtained from the Town of Southbridge Water Department.

(a) Drainage Area. The drainage area tributary to the dam is 1.12 square miles. The pond is surrounded by moderately sloped hills which are heavily forested, and there is no development in the drainage area. Total upstream ponds account for about 4.5 percent of the total watershed.

(b) Discharge at the Dam Site. Normally, water is drawn off from the reservoir through one of the 16-inch water supply inlets at the gatehouse. The 36-inch outlet is utilized only during periods of high flow or to drain the reservoir. Flow over the emergency spillway is intermittent with flashboards generally removed from the middle 40 to 50 percent of the spillway (see Photo No. 7). The combination of the 36-inch diameter outlet and the emergency spillway (with no flashboards) can discharge a total of 3840 cfs with the water surface at the crest of the dam (El 748.0). The routed test flood discharge (one-half PMF) is 1100 cfs at El 745.5 and will not overtop the dam.

The following is a list of pertinent values relative to discharge:

1. Outlet Works (conduit) Size: 36" low level outlet
   3-16" outlets to wet well for
   20" water supply

   Invert Elevation: 36" - 709.5; 16" - 737.3, 729.8, 722.3;
   20" - 710.2
   Discharge Capacity: 36" - 203 cfs; upper 16" - 21 cfs (water surface at top of dam)

2. Maximum Known Flood at Dam Site: Unknown

3. Ungated Emergency Spillway Capacity
   at Top of Dam: 3640 cfs (150' emergency spillway)
   Elevation: 748.0

4. Ungated Emergency Spillway Capacity
   at Test Flood Elevation: 835 cfs
   Elevation: 745.5

5. Gated Spillway Capacity
   at Normal Pool Elevation: N/A
   Elevation: N/A

6. Gated Spillway Capacity
   at Test Flood Elevation: N/A
   Elevation: N/A

7. Total Emergency Spillway Capacity
   at Test Flood Elevation: 835 cfs
   Elevation: 745.5

8. Total Project Discharge
   at Top of Dam: 3860 cfs
   Elevation: 748.0

9. Total Project Discharge
   at Test Flood Elevation: 1100 cfs
   Elevation: 745.5

c. Elevation - Feet Above NGVD (formerly MSL Datum of 1929)

1.	Streambed at Toe of Dam:	715.0
2.	Bottom of Cutoff:	Varies
3.	Maximum Tailwater:	Unknown
4.	Normal Pool:	743.0
5.	Full Flood Control Pool:	N/A
6.	Spillway Crest:	744.0
7.	Design Surcharge - Original Design:	Unknown
8.	Top of Dam:	748.0
9.	Test Flood Surcharge:	745.5

d. Reservoir - Length in Feet

1.	Normal Pool:	1700 feet
2.	Flood Control Pool:	N/A
3.	Spillway Crest Pool:	1700 feet
4.	Top of Dam:	1800 feet
5.	Test Flood Pool:	1750 feet

e. Storage - Acre-Feet

1.	Normal Pool:	380 acre-feet
2.	Flood Control Pool:	N/A
3.	Spillway Crest Pool:	410 acre-feet
4.	Top of Dam:	550 acre-feet
5.	Test Flood Pool:	465 acre-feet

f. Reservoir Surface - Acres

1.	Normal Pool:	28 acres
2.	Flood Control Pool:	N/A
3.	Spillway Crest:	28 acres
4.	Test Flood Pool:	33 acres
5.	Top of Dam:	37 acres

g. Dam

1.	Type:	Earthfill
2.	Length:	1130 feet
3.	Height:	33 feet
4.	Top Width:	18 feet
5.	Side Slopes:	2 Horizontal to 1 Vertical Upstream and Downstream
6.	Zoning:	See Plans in Appendix B
7.	Impervious Core:	Concrete Core Wall
8.	Cutoff:	Sheet Pile (see plans in Appendix B)
9.	Grout Curtain:	None
10.	Other:	Blind Stone Drains (See Plans in Appendix B)

h. Diversion and Regulating Tunnel — N/A

i. Spillway

1.	Type:	Concrete Wall with Flashboards
2.	Length of Weir:	150 feet
3.	Crest Elevation with Flashboards: without Flashboards:	 745.5 744.0
4.	Gates:	N/A
5.	Upstream Channel:	Normal bed of Hatchet Brook
6.	Downstream Channel:	Poorly defined natural channel with an approximate slope of 6:1
7.	General:	Flashboards normally in place over 50 to 60% of spillway length

j. Regulating Outlets

1. Invert:	36" - 709.5; 16" - 737.3, 729.8, 722.3
2. Size:	36", 3-16"
3. Description:	36" used to drain reservoir; 3-16" act as inlets to wet well for 20" water supply outlet
4. Control Mechanism:	3-16" and 20" are controlled by manually operated sluice gates; 36" controlled by manually operated 30" gate valve
5. Other:	Generally only one 16" is open (usually the highest). The 36" is only opened to draw down or drain one reservoir.

SECTION 2
ENGINEERING DATA

2.1 DESIGN DATA

A set of design plans containing 5 sheets for the construction of No. 5 Reservoir Dam was obtained from the Worcester County Engineering Department. The plans were drawn by Fay, Spofford, and Thorndike, Consulting Engineers, Boston, Massachusetts and are dated November 1936 (see Appendix B). The reservoir was designed as part of the Southbridge water supply system and still functions as such. Previous inspection reports and sketches by the Massachusetts Department of Public Works were obtained from the Division of Waterways.

2.2 CONSTRUCTION DATA

No construction records were located for this project. However, the above mentioned plans are in general conformity with the visual inspection of the structure except that the paved interceptor gutter for the blind stone drain at the downstream toe of the embankment was not constructed.

2.3 OPERATING DATA

Daily operating records are taken by the caretaker and maintained in the Southbridge Water Supply Company Office.

2.4 EVALUATION OF DATA

(a) Availability. Documents described above are available from the Worcester County Engineering Department, 2 Main Street, Worcester, Massachusetts, and the Division of Waterways, State of Massachusetts.

(b) Adequacy. The available data, in combination with the visual inspection described in the following section, is adequate for the purpose of the Phase I Investigation.

(c) Validity. With the exception of the discrepancies noted in Section 2.2, the general observed configuration of the dam and appurtenances were in agreement with the construction plans.

SECTION 3
VISUAL INSPECTION

3.1 FINDINGS

(a) General. No. 5 Reservoir was in fair condition at the time of the visual inspection of the dam made on March 5, 1981. The condition of the dam was considered to be fair primarily because of seepage issuing from the downstream toe of slope. A copy of the inspection checklist is included in Appendix A.

(b) Dam. No. 5 Reservoir Dam is an earth embankment with a concrete core wall, approximately 1130 feet in overall length and from 10 to 38 feet high. The dam is concave upstream. The left abutment is a natural hill with possible bedrock outcrops. Soil conditions observed 200 feet upstream of the abutment are sandy, gravelly type soils. The upper portion of the upstream slope of the dam is a rubble stone wall, with a 1 horizontal to 5 vertical tilt backwards towards the dam embankment (see Photos No's. 1, 2, and 5). The stone varies in size from cobbles to small boulders. It is hand placed with no mortar. Some of the stone appears to have ravelled down over the years but for the most part, the rubble wall is intact and in good condition. There is some local and minor depressions of the earth embankment behind the rubble wall, indicating some soil washing into the voids of the rubble. Water level at the time of inspection was 4 feet below the top of the dam. The downstream face of the embankment is covered with grass with no brush or trees (see Photos No's. 3, 4, and 10). At the downstream toe of the embankment, the ground is wet and swampy over an area approximately 50 feet long (measured parallel to the dam axis) and 20 to 30 feet wide, out from the toe. No evidence of live flow was noted at this seepage point which is located approximately 300 feet to the right of the gatehouse (see Photo No. 10).

Approximately 150 feet to the right of the gatehouse there is another swampy area at the downstream toe. Apparently this condition has existed for an appreciable length of time as evidenced by the vegetation at this location.

A third seepage point was noted at the downstream toe about 50 to 100 feet to the right of the gatehouse. The standing water is rust brown in color while the flow is clean and clear and estimated to be on the order of 1 to 5 gpm.

Another low, wet swampy area was noted at the toe of the embankment beginning about 100 feet to the left of the outlet structure, running 50 to 75 feet along the dam.

Standing water appeared stagnant, dark brown in color, and sinks into the ground a short distance from where the flow emanates from the toe of slope. The flow from this area is estimated to be 5 to 10 gpm.

The final swampy area was found at the toe of the embankment beginning approximately 300 feet from the left abutment and extending for approximately 100 feet away from the toe. No flow was observed here.

Evidence of bedrock outcrops were observed immediately downstream of the embankment adjacent to the left third of the dam. Bedrock is closely jointed granite and the joints appear to be tight.

The 36-inch outlet pipe discharges at a headwall structure at the downstream toe of slope (see Photo No. 11). Four observation wells are located in the general vicinity of this structure.

Approximately 150 to 200 feet to the right of the gatehouse is a ledge projection in the pond. Various other bedrock projections were noted in the vicinity of the right abutment.

(c) Appurtenant Structures

(1) Low Level Outlet

This structure which consists of a 36-inch concrete pipe is in good condition. The concrete end walls and dry stone masonry wall extensions are in good condition. No evidence of erosion, spalls, cracks or efflorescence was found on the concrete headwall and wingwalls (see Photo No. 11). The 36-inch wheel operated rising stem gate which controls the outlet flow is reported to be in good condition. At the time of inspection this gate was closed, and there was no evidence of seepage at the outlet.

(2) Gate House

With the exception of minor brick spalling, the walls of this structure are in good condition. With the exception of minor surface erosion, the concrete foundation of this structure is in good condition without any evidence of spalls, cracks or efflorescence (see Photo No. 8). The wood framed roof is in good condition. Five wheel operated bench stands housed within the structure are in good operating condition (see Photo No. 9). At the time of the inspection, one of the 16-inch raw water inlet

gates was fully opened and the 20-inch raw water outlet gate was open for discharge to the water supply system. Steel trash screens are located at the intake end of the structure and are in good condition. The hoisting arm and bracket for removal of the steel trash screens is well maintained

(3) Emergency Spillway

The 150-foot long concrete spillway on the right abutment discharges into an unimproved channel over natural bedrock controlled topography (see Photo No. 7). Stone training walls abut the spillway at each end. Observed outflow at the time of inspection was less than 1 inch deep with flashboards removed from the middle 50 percent of the spillway. Judging from the numerous outcrops upstream and downstream of the weir, the spillway may be founded on bedrock.

With the exception of a transverse crack approximately 1/2-inch wide on this structure, and minor surface erosion, this structure is in good condition without any evidence of spalls, cracks or efflorescence. This crack appears to be a construction joint. The flashboards, which are fabricated from wood planking, are in good condition and well maintained.

(d) Reservoir Area. The reservoir has no development along its shoreline. The surrounding terrain is heavily wooded rolling hills. The shoreline is well maintained. There is little potential that future development will occur in the reservoir area.

(e) Downstream Channel. Discharge from the reservoir flows to No. 4 Reservoir and No. 3 Reservoir. The discharge from No. 3 Reservoir then flows into Hatchet Brook and passes underneath two roadways before reaching the Westville Reservoir Flood Impoundment Area and the Quinebaug River. There is little to no development along the banks of the channel which has a slope of approximately 2.5%.

3.2 EVALUATION

The visual inspection indicates that the dam is in fair condition. There are some deficiencies pertaining mainly to seepage which must be corrected to assure the continued performance of the dam. Items of concern observed during the inspection include seepage along the downstream toe of slope, and minor depressions in the crest behind the upstream riprap protection caused by poor filtering between the soil embankment and stone. Measures to improve the condition are stated in Section 7.3.

SECTION 4
OPERATING AND MAINTENANCE PROCEDURE

4.1 OPERATING PROCEDURES

(a) General Under normal conditions, the valve to the 20-inch water supply line is opened and water is continuously drawn off from the reservoir through one of the 16-inch inlets. The dam is checked daily by the caretaker and records are kept of the water level in the reservoir, temperature, and precipitation. If the precipitation exceeds 1/2 inch, records are taken every 6 hours until the precipitation ceases. Flashboards are installed in the spring after the ice is gone to provide additional storage. The flashboards are removed in July or August after the level of the reservoir has dropped below spillway crest.

(b) Warning System It is understood through verbal discussions that there is an informal warning system in effect at the dam. The system consists of a 24-hour radio call system between the caretaker and the Water Department Superintendent. The Superintendent can call local officials by telephone in the event of an emergency. There are no written procedures for this warning system. The dam is inspected daily by the caretaker and at 6-hour intervals during periods of rainfall in excess of 1/2 inch.

4.2 MAINTENANCE PROCEDURES

(a) General Maintenance of the dam is performed on an informal basis rather than on a formally established routine or procedure. The grass is mowed twice a year. The dam is generally maintained in fair condition.

(b) Operating Facilities Under normal operation, the 20-inch water supply line is opened, and one of the 16-inch supply inlets is opened, depending on the level of water in the reservoir. Flashboards are installed in the spring and removed in the summer. The 30-inch blow-off valve is opened approximately once every two years.

4.3 EVALUATION

The normal operating procedure has been developed to provide a constant supply of water to the Town of Southbridge. Maintenance of the facility is performed on an informal basis and the overall maintenance procedure should be expanded and refined to include monitoring of seepage issuing from the downstream toe of slope. A formal maintenance procedure should be established including the items enumerated in Section 7.3. A formal written downstream warning plan should be developed, and an annual program of technical inspections by a qualified registered professional engineer should be implemented.

SECTION 5
EVALUATION OF HYDRAULIC/HYDROLOCIC FEATURES

5.1 General. No. 5 Reservoir Dam is a 33-foot high, 1130-foot long earthfill dam built in 1938. It reportedly has a concrete core wall. The spillway is a 150-foot long broad crested concrete weir with rod supports for flashboards.

The reservoir is fed by Hatchet Brook and has a normal surface area of 28 acres. The watershed is 1.12 square miles of rolling terrain and includes Hatchet Pond. The slope of the drainage area is about 2.1 percent.

5.2 Design Data. Hydraulic or hydrologic computations are not available for the design of the spillway.

5.3 Experience Data. Daily records of water level, and rainfall, for No. 5 Reservoir are kept by the Southbridge Water Supply Company. During periods of rainfall in excess of 1/2 inch, records are taken at 6-hour intervals. These records are available for review at the Town of Southbridge Water Supply Company.

5.4 Test Flood Analysis. Based on the Corps of Engineers Guidelines, the recommended test flood range for the size (small) and hazard (significant) is a 100-year frequency to 1/2 Probable Maximum Flood (PMF). Because a failure of the dam would cause a loss of water supply and an appreciable economic loss, 1/2 PMF was adopted as the test flood inflow. The watershed has mostly rolling terrain with a gentle slope (about 2.1%) and a considerable amount of upstream ponded water (about 4.5% of the total drainage area) and marshland (another 2.0%). Applying 1/2 the PMF (1063 CSM) to the 1.12 square miles of drainage area results in a calculated peak flood flow of 1190 cfs as the inflow test flood. By adjusting the inflow test flood for surcharge storage, the maximum discharge rate was established as 1100 cfs, with a water surface at El 745.5. As the top of the dam is at El 748.0, the routed test flood outflow would result in a freeboard of 2.5 feet. Without flashboards, the emergency spillway capacity with the water surface at the top of the dam is 3640 cfs, which represents 330% of the test flood outflow.

5.5 Dam Failure Analysis. Based on the Corps of Engineers Guidelines for Estimating Dam Failure Hydrographs, and assuming a breach width of 280 feet which represents 40 percent of the mid-height length of 700 feet at a water surface elevation of 745.5, the dam failure outflow would be 80,400 cfs. This includes discharge from the spillway. Using the calculations from Phase I Reports on the two downstream dams, it is estimated that as a result of a

dam failure at No. 5 Reservoir, No. 4 Reservoir would be overtopped by approximately 3.7 feet and No. 3 Reservoir would be overtopped by approximately 1.7 feet. Neither of these dams would be overtopped due to outflow from No. 5 Reservoir prior to failure. Consequently, failure of both downstream dams would be likely. Downstream from Reservoir No. 3 the failure outflow would be approximately 5.8 feet deep for the typical downstream section. This approximate depth would carry downstream approximately 7000 feet from No. 3 Reservoir before reaching the Westville Reservoir Flood Impoundment Area where the failure outflow would be attenuated. Consequently, with an appreciable economic loss and a loss of water supply, the overall potential hazard from a dam failure of Reservoir No. 5 would be "significant".

SECTION 6
EVALUATION OF STRUCTURAL STABILITY

6.1 VISUAL OBSERVATIONS

Field inspection of the dam and spillway indicates that these structures are in fair condition. There has been no significant displacement or distress which would warrant the preparation of structural stability calculations. Vegetation on the downstream face is grass, with small brush, apparently trimmed regularly. The spillway and outlet channel are constructed on shallow sandrock. Seepage was noted issuing from several stretches along the toe of the embankment, particularly near the center of the dam. Flow was clean and estimated to be in the order of 1 to 5 gpm. Crude observation wells were noted in the swampy area just downstream of the toe. Minor depressions were noted in the embankment soil of the crest, immediately behind the upstream face riprap stone.

6.2 DESIGN AND CONSTRUCTION DATA

Definitive plans of the dam and spillway were reviewed. The drawings consist of 5 sheets developed by Fay, Spofford & Thorndike, Inc., Consulting Engineers, Boston, Massachusetts, dated December 11, 1936. The plans generally appear to be consistent with the superficial features observed during the field inspection. The one visible departure from the drawings was the lack of a drainage ditch to collect water from the blind stone drains. Laboratory test data of the soils forming the embankments was not available. Calculations pertaining to the stability of the dam and spillway are also not available.

6.3 POST-CONSTRUCTION CHANGES

There are no records of any post-construction changes to the dam or the spillway.

6.4 SEISMIC STABILITY

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

SECTION 7
ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 DAM ASSESSMENT

(a) Condition. No. 5 Reservoir is in fair condition at the present time. It could not be determined whether the seepage emanating from the downstream toe is directly attributable to collected seepage channeled by the blind stone drains or to other seepage through the dam structure or foundation. Minor depressions in the crest behind the upstream riprap rock slope protection are indicative of poor filtering between the soil embankment and stone. This is considered primarily a maintenance problem. Seepage observed at the toe will require further indepth investigation and engineering studies as outlined below.

(b) Adequacy of Information. The original design drawings are available for the embankment and spillway. Consequently, the adequacy of engineering data is considered good. The assessment of this dam is based on a knowledge of these design drawings plus the visual inspection conducted on March 5, 1981.

(c) Urgency. The remedial measures enumerated in Section 7.3 below should be implemented by the owner within one year of receipt of this Phase I inspection report.

7.2 RECOMMENDATIONS

It is recommended that the owner engage a registered professional engineer experienced in the design and construction of embankment dams to undertake an investigation of the source of seepage emanating from the toe. If the source is identified as the stone drains, a collector trench, as originally proposed in the design is recommended. If the source of seepage is through the dam embankment or foundation, further studies will be required.

The Owner should implement the recommendations of the Engineer.

7.3 REMEDIAL MEASURES

(a) Operation and Maintenance Procedures. In addition to the initiating of the studies recommended above, the following items should be implemented to assure the continued performance of the dam.

(1) Implement a program of yearly technical inspections by a qualified registered professional engineer.

(2) Develop an "emergency preparedness plan" that will include an effective preplanned downstream warning system, locations of emergency equipment, materials and manpower, authorities to contact, and potential areas that may require evacuation.

(3) Fill all minor depressions in crest behind the upstream riprap rock slope protection with compacted gravel.

(4) Monitor seepage on a weekly basis with particular attention paid to any change in the quantity or clarity until the recommendations of the engineering study have been implemented.

7.4 ALTERNATIVES

There are no practical alternatives to the above recommendations and remedial measures.

APPENDIX A

INSPECTION CHECKLISTS

INSPECTION TEAM ORGANIZATION

Date: March 5, 1981

Project: MA 00693
No. 5 Reservoir
Southbridge, Massachusetts

Weather: Clear, cold

INSPECTION TEAM

Kenneth W. Hodgson, Jr.	Cullinan Engineering Co., Inc. (CEC)	Team Captain
Gregory M. Valiton	CEC	Hydraulics
Steven J. Trettel	Goldberg, Zoino & Associates (GZ)	Soils
Andrew Christo	Andrew Christo Engineers, Inc. (ACE)	Structures
Paul Razgha	ACE	Structures
Carl Razgha	ACE	Structures

Owner was not represented at inspection

NOTE: Observed water surface elevation in reservoir at time of inspection = El 744.0±

No. 5 Reservoir Dam
MA 00693

March 5, 1981

CHECKLISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION AND REMARKS
UPSTREAM SLOPE		
Vegetation	GZ	None
Sloughing or Erosion		None
Rock Slope Protection -		
Riprap Failures		Good
Animal Burrows		None
CREST		
Vegetation		Grass growth
Sloughing or Erosion		None
Surface Cracks		None
Movement or Settlement		None
DOWNSTREAM SLOPE		
Vegetation		Grass growth
Sloughing or Erosion		None
Surface Cracks		None
Animal Burrows		None
Movement or Cracking Near Toe		None
Unusual Embankment or Downstream Seepage		Five seepage areas, possibly from blind stone drains

No. 5 Reservoir Dam
MA 00693

March 5, 1981

CHECKLISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION AND REMARKS
Piping or Boils		None
Foundation Drainage Features		Blind stone drains outletting at toe of slope
Toe Drains		None
GENERAL		
Lateral Movement		None
Vertical Alignment		Good
Horizontal Alignment		Good
Condition at Abutments and at Structures		Good
Indications of Movement of Structural Items		None
Trespassing		None
Instrumentation Systems	GZ	None
PRINCIPAL SPILLWAY		
Waste Gate	ACE	Good
36-Inch Outlet		Good
Headwall and Wingwalls		Good
Condition of Concrete		Good
Spalling		None noted
Erosion		None noted
Cracking		None noted
Efflorescence		None noted

No. 5 Reservoir Dam
MA 00693

March 5, 1981

CHECKLISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION AND REMARKS
Rusting or Staining of Concrete		None noted
Visible Reinforcing		None noted
Stone Walls		Good
GATE HOUSE		
Building		Minor surface spalls of brick. Roof in good condition.
Gates		Good
Foundation		
Condition of Concrete		Good
Spalling		None noted
Erosion		Minor at water line
Cracking		None noted
Efflorescence		None noted
Rusting or Staining of Concrete		None noted
Visible Reinforcing		None noted
EMERGENCY SPILLWAY		
Condition of Concrete		Good
Spalling		None noted
Erosion		Minor on surface
Cracking		Vertical transverse crack 1/2"± wide

No. 5 Reservoir Dam
MA 00693

March 5, 1981

CHECKLISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION AND REMARKS
Efflorescence		None noted
Rusting or Staining of Concrete		None noted
Visible Reinforcing	ACE	None noted

APPENDIX B

ENGINEERING DATA

DESCRIPTION OF DAM

DISTRICT 3

Submitted by R. Nichols & S. Mace Dam No. 3-14-278-18

Date 3-8-73 ~~City~~/Town SOUTHBRIDGE

Name of Dam #5 RESERVOIR

1. Location: Topo Sheet No. 13 D

Provide 8½" x 11" in clear copy of topo map with location of Dam clearly indicated.

2. Year built: 1938 Year/s of subsequent repairs _____

3. Purpose of Dam: Water Supply ✓ Recreational _____

Irrigation _____ Other _____

4. Drainage Area: 1.03 sq. mi. _____ acres

5. Normal Ponding Area: 30 acres; Ave. depth _____

Impoundment: 159,000,000 gals.; _____ acre ft.

6. No. and type of dwellings located adjacent to pond or reservoir

1 GATE HOUSE i.e. summer homes, etc. _____

7. Dimensions of Dam: Length 1500' Max. Height 38'

Slopes: Upstream Face 2:1

Downstream Face 2:1

Width across top 18'

8. Classification of Dam by Material:

Earth ✓ Conc. Masonry ✓ Stone Masonry _____

Timber _____ Rockfill _____ Other CONC. MAS. CORE

9. A. Description of present land usage downstream of dam:

100 % rural; _____ % urban.

B. Is there a storage area or flood plain downstream of dam which could accomodate the impoundment in the event of a complete dam failure? yes ✓ no _____.

DAM NO. 3-14-678-13

10. Risk to life and property in event of complete failure.

No. of people NONE.

No. of homes NONE.

No. of Businesses NONE.

No. of industries NONE. Type _____

No. of utilities WATER CO (SAFETY. Type _____

Railroads NONE.

Other dams 3-14-678-17 & 3-14-678-16.

Other NONE.

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

12. How to Locate: FROM THE INTERSECTION OF SCR 5 & BREAKNECK RD. 1.9 MILES ON BREAKNECK TO GATE ON LT. - DAM IS PERPENDICULAR & ADJACENT TO RD.

INSPECTION REPORT - DAMS AND RESERVOIRS

1. Location: ~~City~~/Town SOUTHBRIDGE Dam No. 3-14-276-15

Name of Dam #5 RESERVOIR Inspected by [illegible]

Date of Inspection 2-8-73

2. Owner/s: per: Assessors _____ Prev. Inspection _____

Reg. of Deeds _____ Pers. Contact ✓

1. SOUTHBRIDGE WATER SUPPLY CO. 76 [illegible], SOUTHBRIDGE, MA. 01550
Name 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. Caretaker (if any) e.g. superintendent, plant manager, appointed by absentee owner, appointed by multi owners.

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. Outlet Control: Automatic _____ Manual ✓

Operative ✓ yes; _____ No.

Comments:

7. Upstream Face of Dam: Condition:

1. Good ✓ 2. Minor Repairs _____

3. Major Repairs ___ 4. Urgent Repairs ___

or Comments:

Dam NO. 3-17-275-16

8. Downstream Face of Dam:

Condition: 1. Good ✓ 2. Minor Repairs _____

3. Major Repairs ____ 4. Urgent Repairs _____

Comments:

9. Emergency Spillway:

Condition: 1. Good _____ 2. Minor Repairs _____

3. Major Repairs ____ 4. Urgent Repairs _____

Comments:

10. Water Level at time of inspection: 4 ft. above____below ✓

top of dam ✓ principal spillway_____

other_____

11. Summary of Deficiencies Noted:

Growth (Trees and Brush) on Embankment NONE

Animal Burrows and Washouts NONE

Damage to slopes or top of dam NONE

Cracked or Damaged Masonry NONE

Evidence of Seepage NONE

Evidence of Piping NONE

Erosion NONE

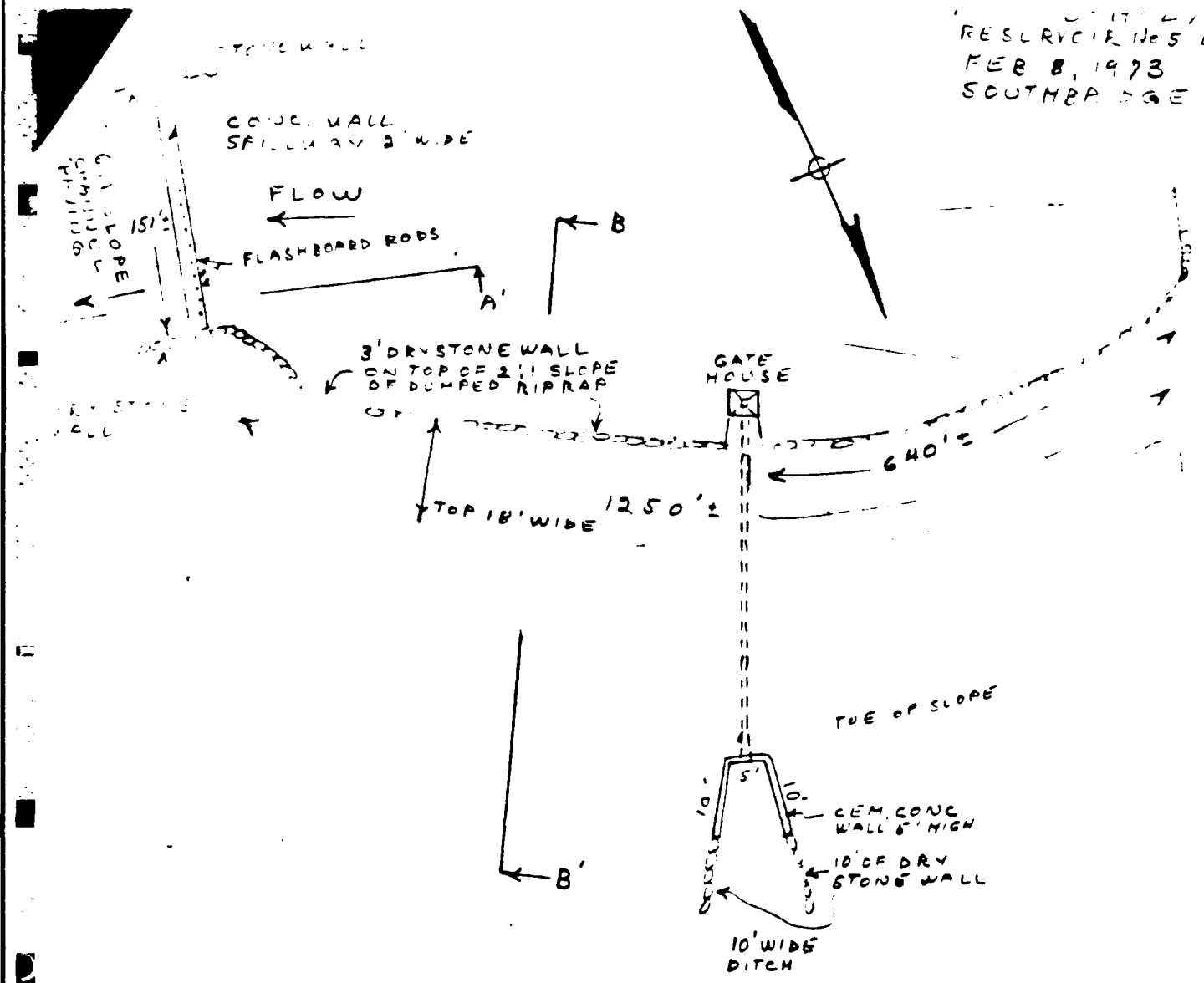
Leaks NONE

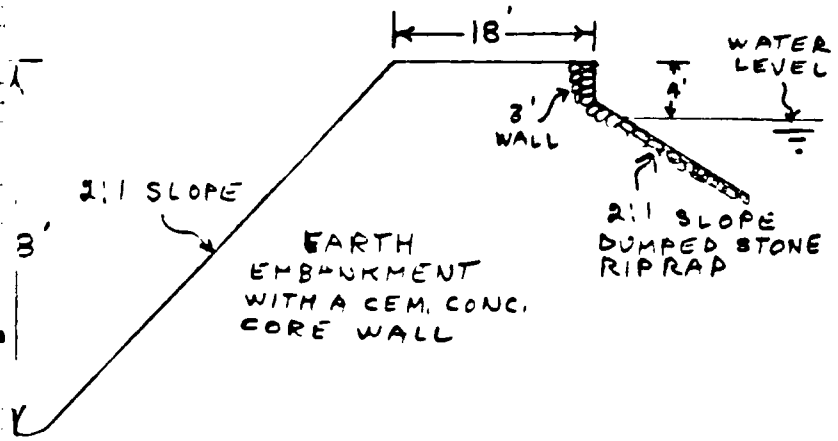
Trash and/or debis impeding flow NONE

Clogged or blocked spillway NO

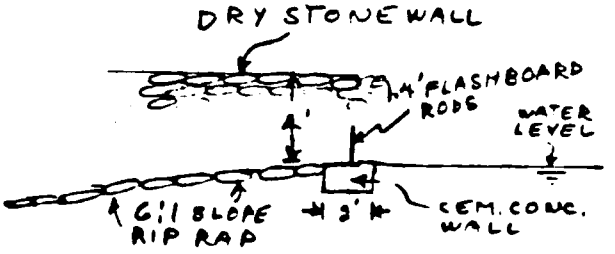
Other BRUSH IN SPILLWAY CHANNEL

RESERVOIR No 5 DAM
FEB 8, 1973
SOUTHBOUND

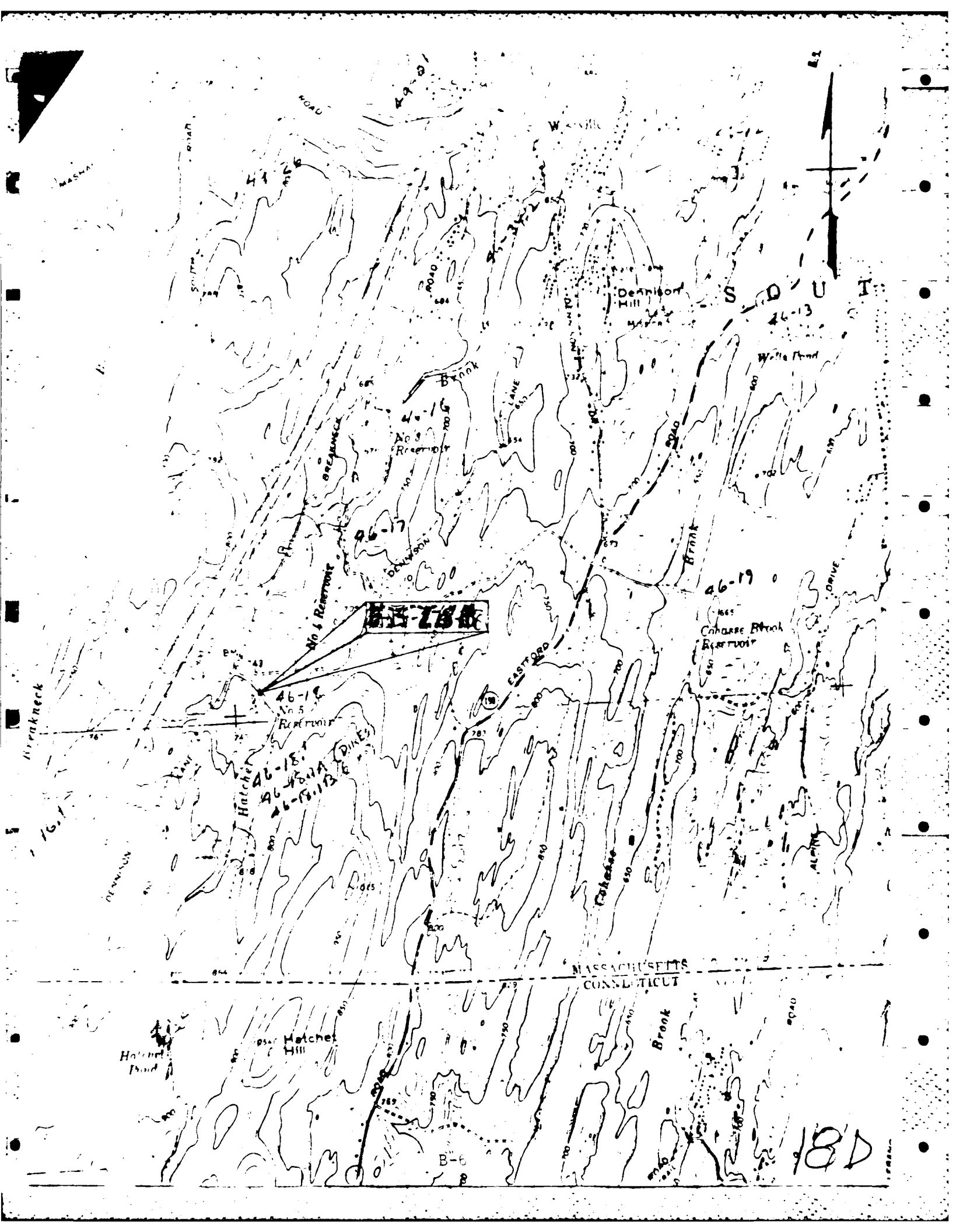




SECTION B-B'



SECTION A-A'


S O U T
Dennison Hill
No 3 Reservoir
No 4 Reservoir
No 5 Reservoir
Cohasse Brook Reservoir
EASTFORD
MASSACHUSETTS
CONNECTICUT
Hatchet Hill
B-6
18D

 DAM NO. 3-14-278-16

12. Remarks and Recommendations: (Fully Explain)

THE DAM IS WELL MAINTAINED - WHAT MIGHT APPEAR TO BE SEEPAGE AT THE TOE OF SLOPE IS ACTUALLY DRAINAGE FROM THE BLIND-STONE DRAINS PLACED AT REGULAR INTERVALS IN THE DAM CONSTRUCTION - THE ONLY IRREGULARITY NOTED REQUIRING ATTENTION IS THE VERTICAL PLANE CRACK IN THE SPILLWAY CHANNEL.

13. Overall Condition:

1. Safe _____
2. Minor repairs needed ✓
3. Conditionally safe - major repairs needed _____
4. Unsafe _____
5. Reservoir impoundment no longer exists (explain)

   Recommend removal from inspection list _____

April 11, 1973

Southbridge Water Supply Co.
90 Power Street
Southbridge, Massachusetts 01550

RE: Inspection Report No. 73-18
Southbridge
#5 Reservoir Dam

Gentlemen;

An engineer from the Massachusetts Department of Public Works has inspected the above dam, owned by the Southbridge Water Supply Co.

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

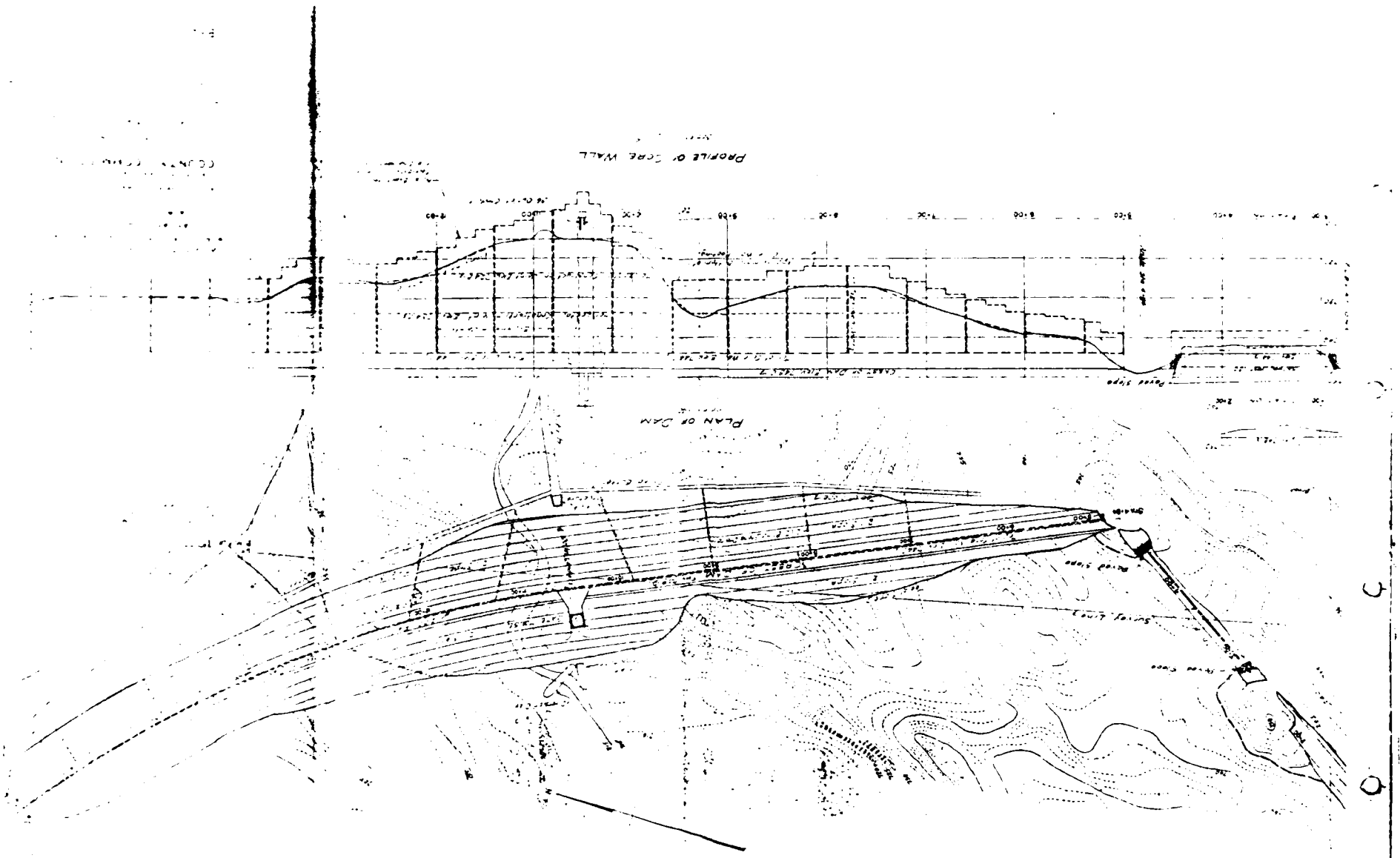
The results of the inspection indicate that this dam is safe however, the widespread brush growth in the spillway channel should be removed.

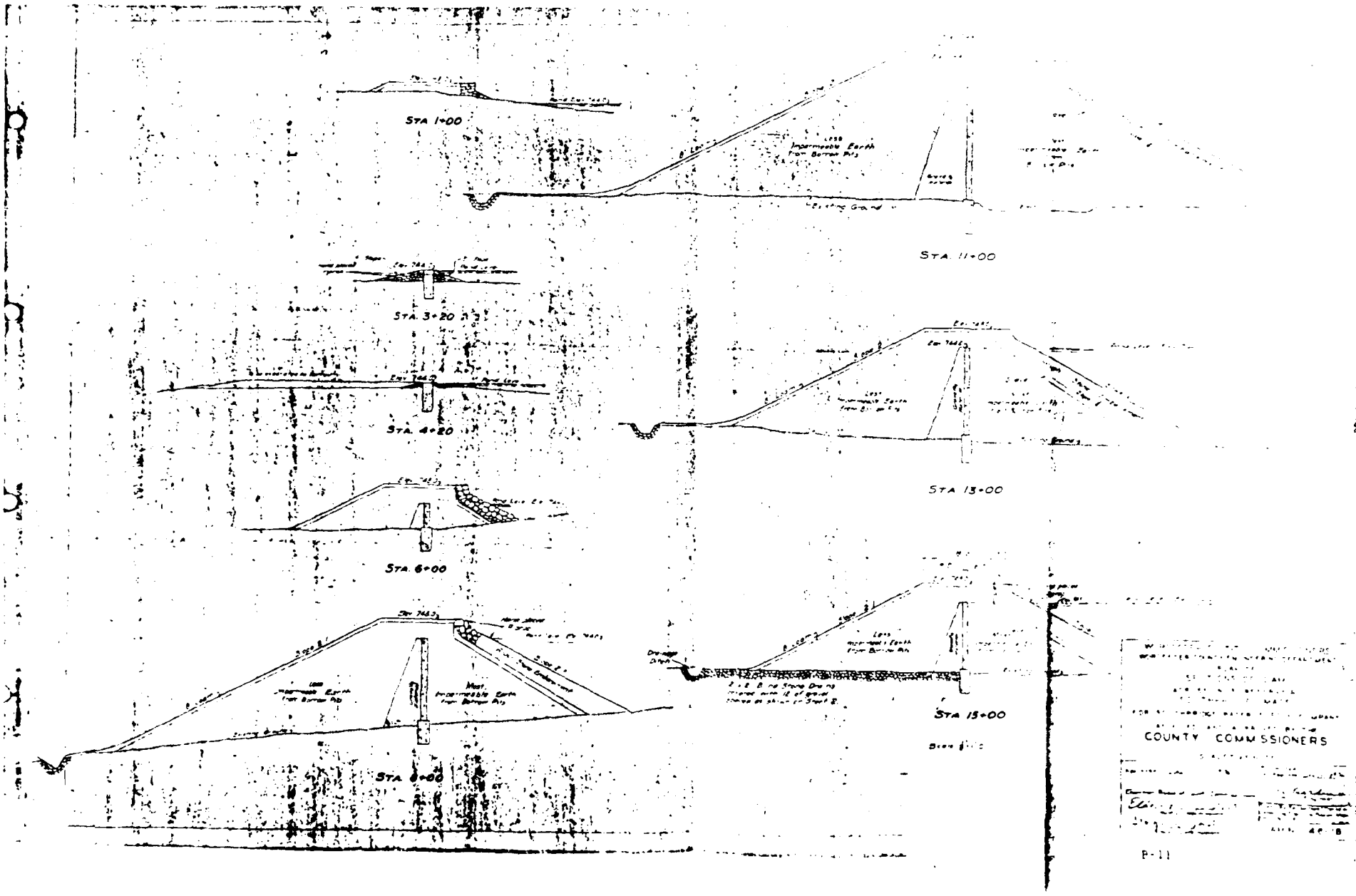
We call this condition to your attention now, before it becomes serious and expensive to correct.

Very truly yours,

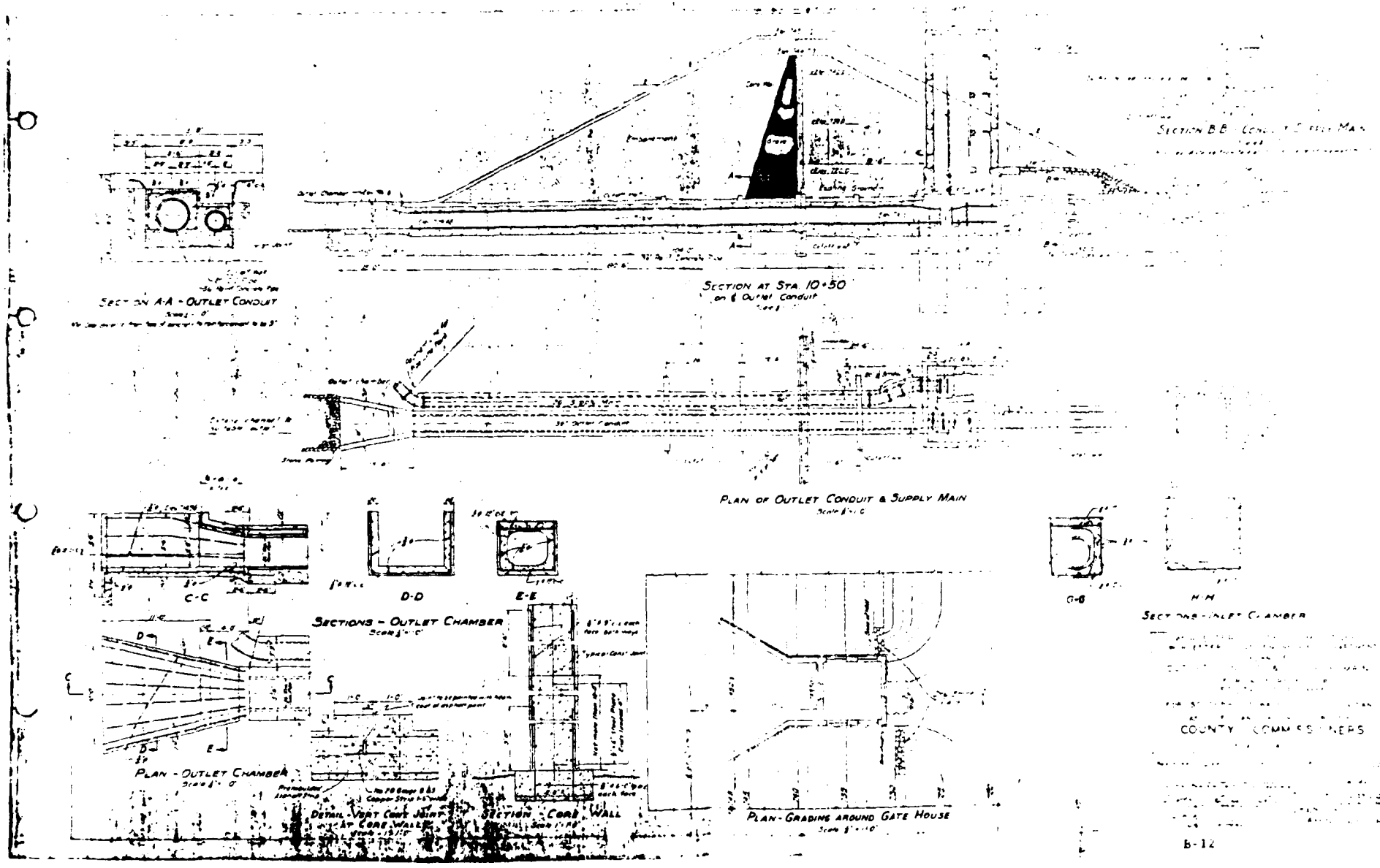
Fred C. Schaffner
Wm. C. [illegible], P.E.
Deputy Chief Engineer

LEL
IRA/afs
cc: O. E. Aylward [illegible]
A. Trevisan [illegible]


PROFILE OF CORE WALL
PLAN OF DAM


STA 1+00
STA 3+20
STA 4+20
STA 6+00
STA 8+00
STA 11+00
STA 13+00
STA 15+00
COUNTY COMMISSIONERS

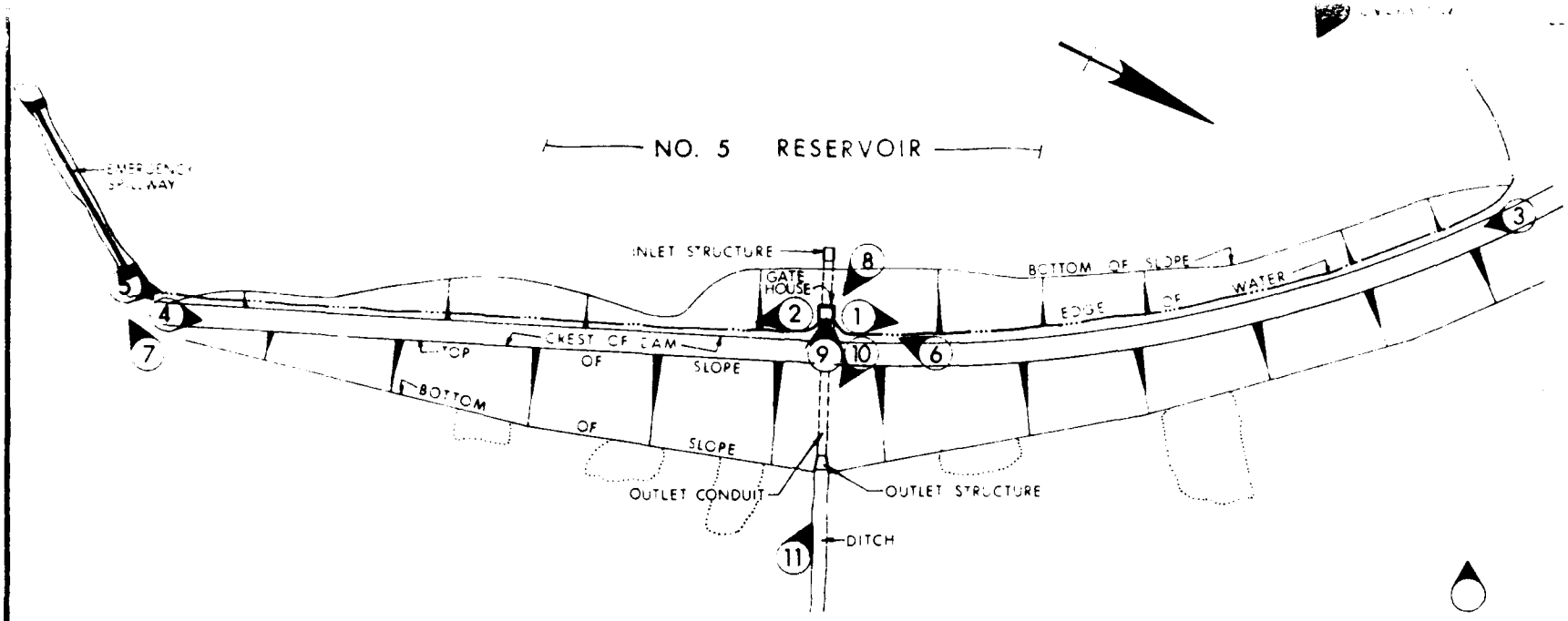
P-11



COUNTY COMMISSIONERS

APPENDIX C

PHOTOGRAPHS



PLAN

NO SCALE

DENOTES PHOTO NUMBER AND DIRECTION IN WHICH PHOTO WAS TAKEN

NOTE : PHOTO NO 9 TAKEN INSIDE GATE HOUSE

DENOTES APPROXIMATE LOCATIONS WHERE SEEPAGE WAS OBSERVED

U S ARMY CORPS OF ENGINEERS
NEW ENGLAND DIVISION
WALTHAM, MASSACHUSETTS

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

PHOTO LOCATION PLAN
NO. 5 RESERVOIR
SOUTHBRIDGE, MASS.

SCALE NO SCALE		DATE MARCH 1981	
DWN NP	CKD GV	APP KH	PAGE C 1

CULLINAN ENGINEERING CO., INC.
CIVIL ENGINEERS
AUBURN, BOSTON, MASSACHUSETTS

PHOTO NO. 1
VIEW OF LEFT UPSTREAM FACE
FROM GATE HOUSE

PHOTO NO. 2
VIEW OF RIGHT UPSTREAM FACE
FROM GATE HOUSE

U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION WALTHAM, MASSACHUSETTS	NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	No. 5 Reservoir Dam Hatchet Brook Southbridge, Mass. MA 00693 March 5, 1981
CULLINAN ENGINEERING CO., INC. CIVIL ENGINEERS AUBURN-BOSTON, MASSACHUSETTS		

PHOTO NO. 3
VIEW OF LEFT DOWNSTREAM FACE
FROM LEFT END

PHOTO NO. 4
VIEW OF RIGHT DOWNSTREAM FACE
FROM RIGHT END

U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION WALTHAM, MASSACHUSETTS	NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	No. 5 Reservoir Dam Hatchet Brook Southbridge, Mass. MA 00693 March 5, 1981
CULLINAN ENGINEERING CO., INC. CIVIL ENGINEERS AUBURN-BOSTON, MASSACHUSETTS		

PHOTO NO. 5
VIEW OF UPSTREAM FACE
FROM RIGHT END

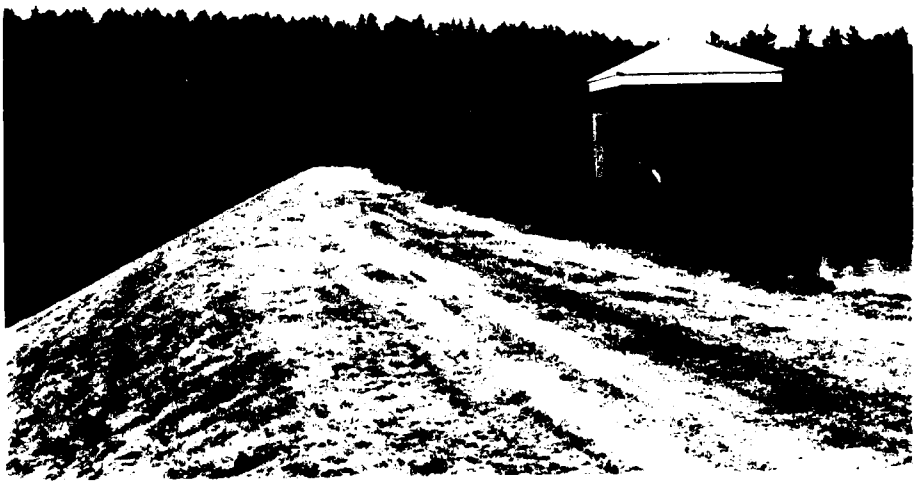


PHOTO NO. 6
VIEW OF GATE HOUSE
FROM LEFT SIDE

U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION WALTHAM, MASSACHUSETTS	NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	No. 5 Reservoir Dam Hatchet Brook Southbridge, Mass. MA 00693 March 5, 1981
CULLINAN ENGINEERING CO., INC. CIVIL ENGINEERS AUBURN-BOSTON, MASSACHUSETTS		

PHOTO NO. 7
VIEW OF EMERGENCY SPILLWAY - NOTE FLASHBOARDS REMOVED OVER APPROXIMATELY 50% OF LENGTH

PHOTO NO. 8
VIEW OF UPSTREAM SIDE OF GATE HOUSE - NOTE BAR SCREEN FOR RAW WATER INTAKE LINES

U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION WALTHAM, MASSACHUSETTS	NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	No. 5 Reservoir Dam Hatchet Brook Southbridge, Mass. MA 00693 March 5, 1981
CULLINAN ENGINEERING CO., INC. CIVIL ENGINEERS AUBURN-BOSTON, MASSACHUSETTS		

PHOTO NO. 9
VIEW OF OPERATORS INSIDE GATE HOUSE -
NOTE CHAINFALL FOR LIFTING SCREENS AND ACCESS OPENING TO WELL

PHOTO NO. 10
VIEW DOWNSTREAM OF DAM - NOTE OUTLET CHANNEL AT LEFT OF PICTURE
AND DISCHARGE FROM BLIND STONE DRAINS AT RIGHT OF PICTURE

U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION WALTHAM, MASSACHUSETTS	NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	No. 5 Reservoir Dam Hatchet Brook Southbridge, Mass. MA 00693 March 5, 1981
CULLINAN ENGINEERING CO., INC. CIVIL ENGINEERS AUBURN-BOSTON, MASSACHUSETTS		

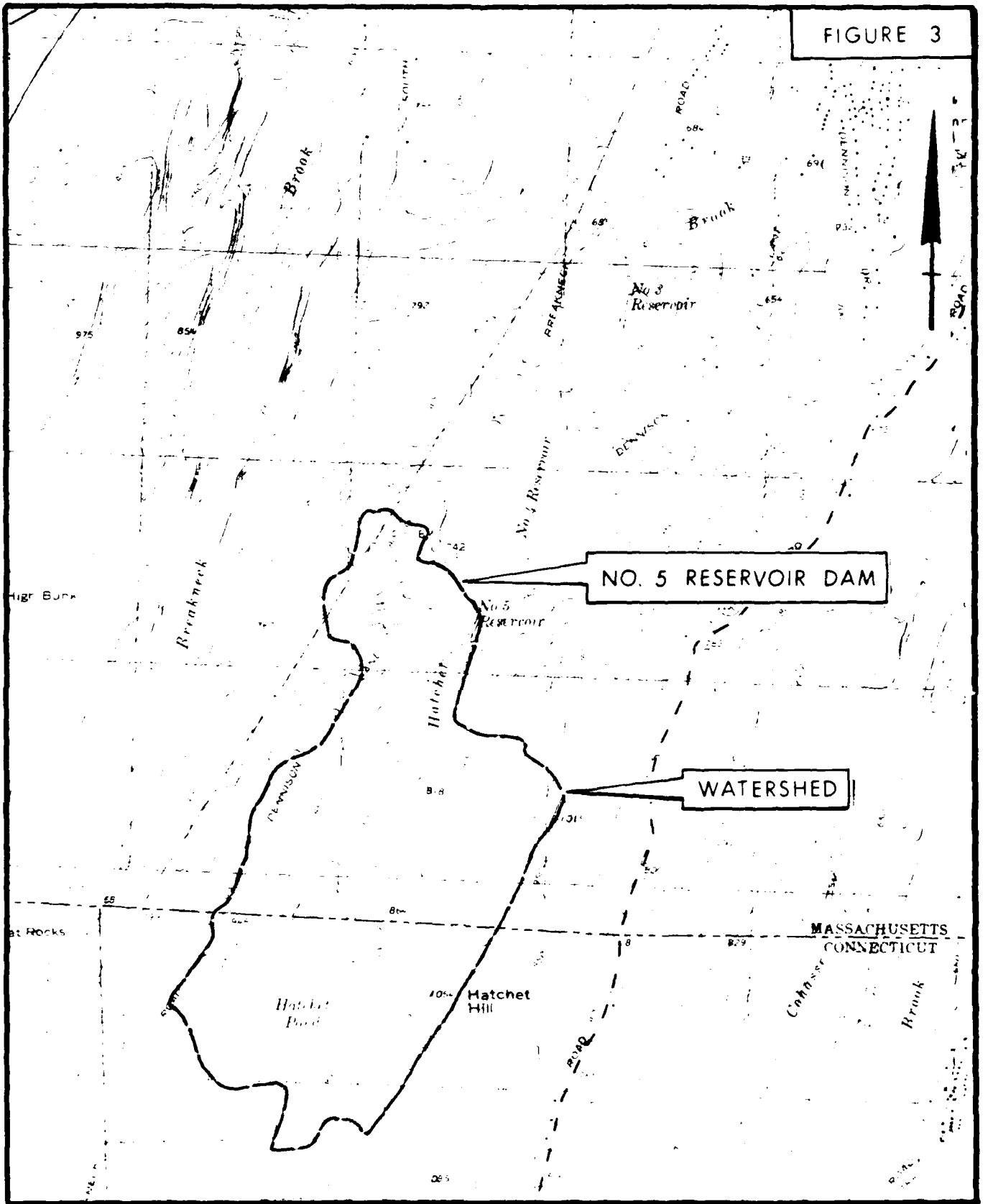
PHOTO NO. 11
VIEW OF HEADWALL FOR RESERVOIR
DRAIN OUTLET LOOKING UPSTREAM

U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION WALTHAM, MASSACHUSETTS	NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	No. 5 Reservoir Dam Hatchet Brook Southbridge, Mass. MA 00693 March 5, 1981
CULLINAN ENGINEERING CO., INC. CIVIL ENGINEERS AUBURN-BOSTON, MASSACHUSETTS		

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

FIGURE 3

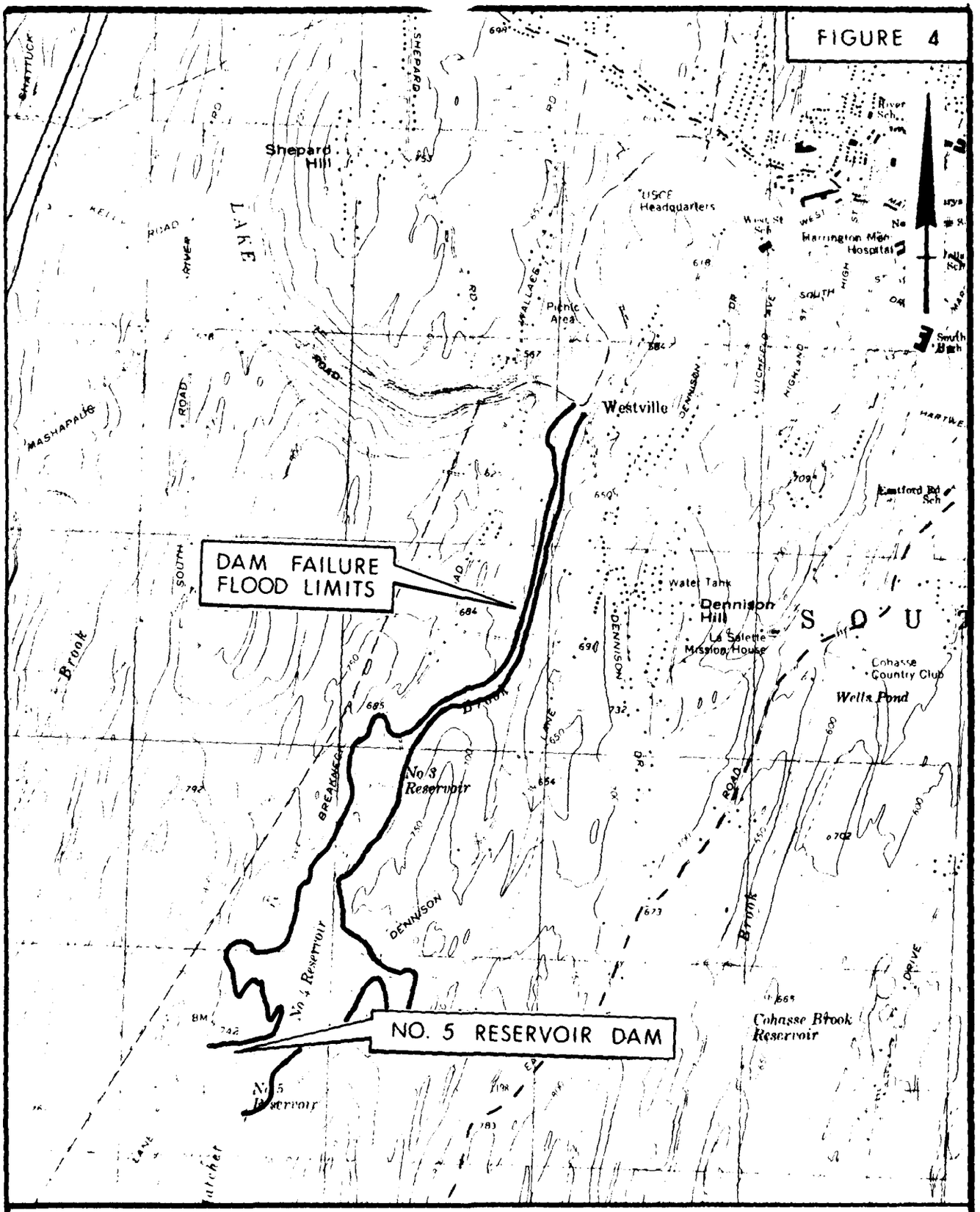


WATERSHED

NO. 5 RESERVOIR DAM
SOUTHBRIDGE, MASS.
1" = 2083'

CULLINAN ENGINEERING CO., INC. SOUTHBRIDGE, MASS., CONN. QUADRANGLE 1979

FIGURE 4



DAM FAILURE FLOOD LIMITS
NO. 5 RESERVOIR DAM
SOUTHBRIDGE , MASS.
1 " = 2083 '

CULLINAN ENGINEERING CO., INC. SOUTHBRIDGE, MASS, CONN QUADRANGLE 1979

CLIENT / PROJECT U.S. Army COE / Non-Federal Dams DATE 2/11/81 JOB NO

SUBJECT Reservoir No. 5 Analysis and Evaluation BY GMV CHKD BY SHEET 1 OF 14

I. Classification:

Size: Storage (max) = 530 Ac. Ft. ∴ Small
Height (Struct.) = 38 Ft. ∴ Small

Hazard Potential: Analysis indicates that if failure were to occur with the water surface at the top of the dam, hazard potential would be Significant due to loss of water supply and possible damage to two dams downstream

II. Spillway Design Flood:

"With a significant hazard potential and a small dam, the COE "Recommended Guidelines for Safety Inspection of Dams" indicates that a test flood in the 100 Year Frequency to ½ Probable Maximum Flood range is appropriate for evaluation (½ PMF was used for Res. No. 4 Phase I Report).

∴ Determine SDF using ½ PMF

III. Inflow Hydrograph:

Tributary Area = 714 Acres = 1.12 Sq. Miles
Terrain is Rolling (from inspection of USGS Southbridge Quad)
∴ From COE "Maximum Probable Flood Peak Flow Rates"
PMF (csm) = 2125 CSM (25 Sq. Mile Minimum)
∴ SDF = ½ PMF = 0.5 × 2125 × 1.12 = 1190 cfs

Time to peak $t_p = \frac{484AQ}{q_p}$

Where: A = Drainage Area = 1.12 Sq. Miles
Q = Total Runoff = 9.5 In. ($\frac{PMF}{2}$)
q_p = Peak Flow = 1190 cfs

∴ $t_p = \frac{484 \times 1.12 \times 9.5}{1190} = 4.3$ hrs. (260 Min.)

Time base for hydrograph $t_b = 2.67\, t_p$

∴ $t_b = 2.67 \times 4.3 = 11.6$ hrs. (694 Min.)

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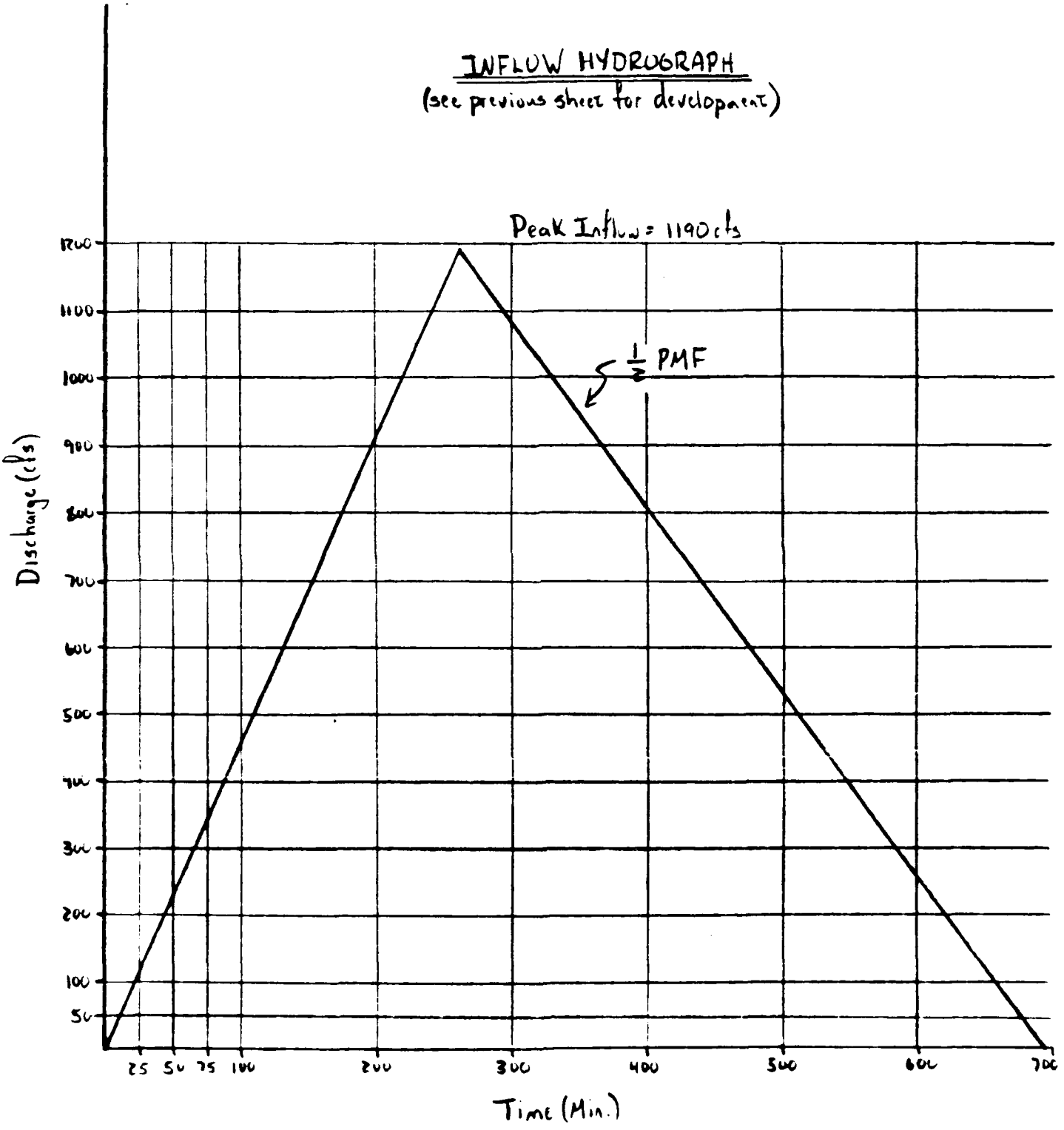
SUBJECT Reservoir No. 5 Analysis and Evaluation BY GMV CHKD BY JDP SHEET 2 OF 14

INFLOW HYDROGRAPH

(see previous sheet for development)



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IV Flood Routing

Stage Discharge Data – Information used to develop the stage discharge data is from the 193[illegible] Contract Drawings, conversations with a representative of the owner, and field observations.

Outlets – The Contract Drawings indicate that 3-16" ϕ outlets at varying elevations exist in the gate structure and that a single 36" ϕ outlet exists under the embankment to drain the reservoir. In addition, there is approximately 150 ft. of emergency spillway and 1130 ft. of embankment. Conversations with a representative of the owner indicate that only one (usually the highest) of the 16" ϕ outlets is usually open and that the 36" ϕ outlet would only be used to drain the reservoir [illegible].

∴ 36" Outlet @ El. 710.6± — $K_e = 0.5$, $L = 150'$± — * Q = from Outlet Control Nomographs [illegible] in HEC-5

16" Outlet @ El. 737.3± — Q = from Inlet Control Nomographs contained in HEC-5

150' Emergency Spillway @ El. 744.0 — $Q = 3.02\,LH^{3/2}$

1130' Embankment @ El. 7[illegible].0 — $Q = 3.02\,LH^{3/2}$

ASSUME WS @ El. 743 (from USGS) @ START OF STORM, 36 Gate Opened at this point

ELEV.	H_{36}	H_{16}	H_s	H_E	Q_{36}	Q_{16}	Q_s	Q_E	Q_{total}
744	33.4'	6.7'	–	–	192 cfs	16 cfs	–	–	208 cfs
745	34.4'	7.7'	1'	–	194 cfs	18 cfs	455 cfs	–	667 cfs
746	35.4'	8.7'	2'	–	197 cfs	19 cfs	1285 cfs	–	1501 cfs
747	36.4'	9.7'	3'	–	200 cfs	20 cfs	2362 cfs	–	2582 cfs
748	37.4'	10.7'	4'	–	203 cfs	21 cfs	3636 cfs	–	3860 cfs
749	38.4'	11.7'	5'	1'	205 cfs	22 cfs	5081 cfs	3424 cfs	8732 cfs
750	[illegible]	12.7'	6'	2'	208 cfs	23 cfs	6680 cfs	9684 cfs	16595 cfs

@ El. 743 [illegible] the 16" [illegible] would be discharging $Q_{16} = 14$ cfs

* For [illegible] use $H = \left[1.5 - \frac{29n^2L}{R^{1.33}}\right]\frac{V^2}{2g}$

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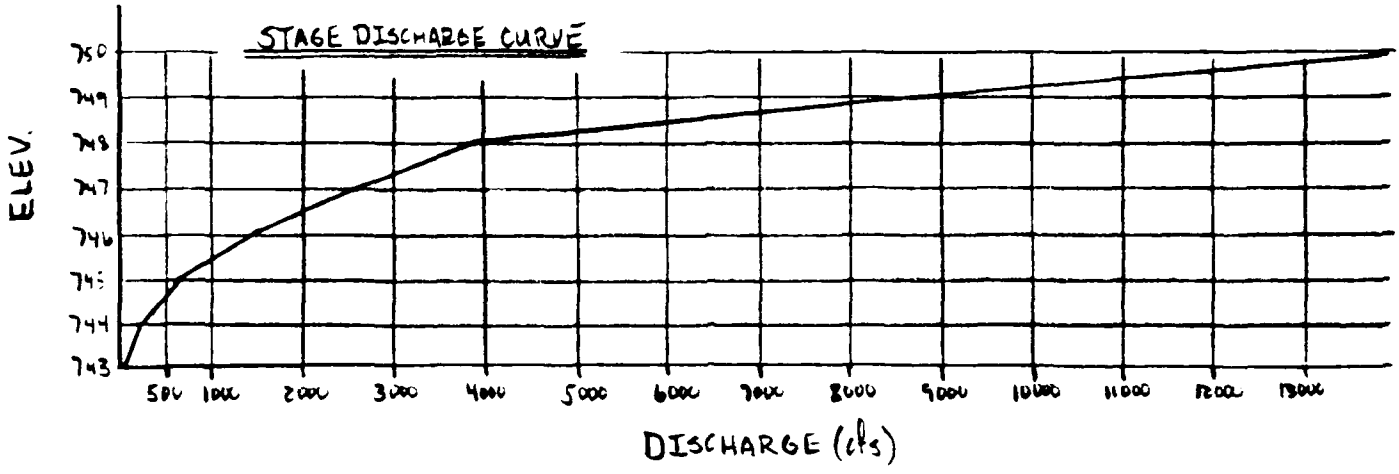
IV. Flood Routing: cont.

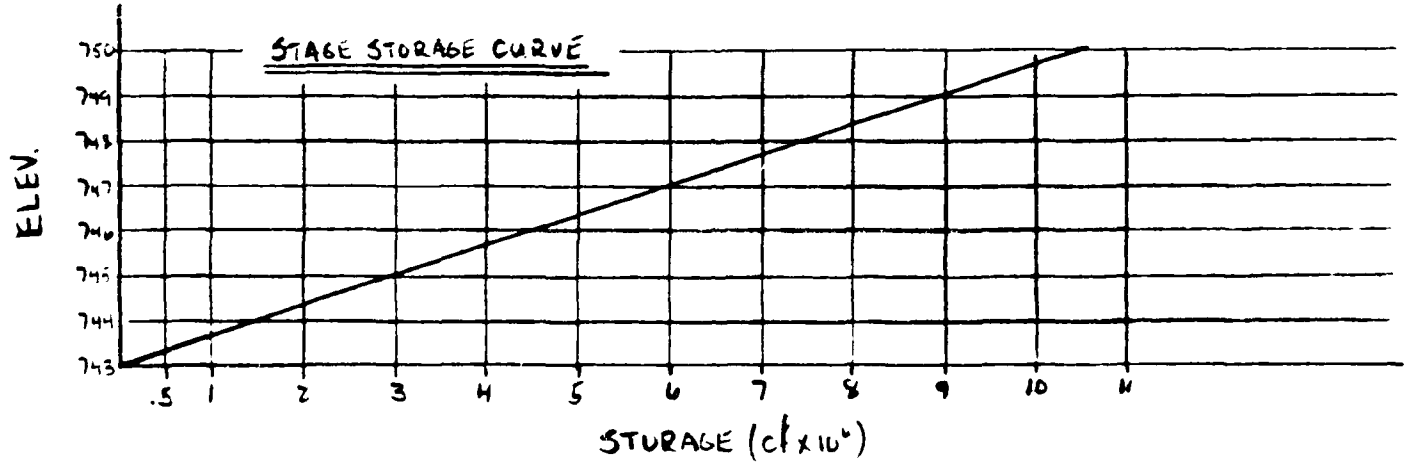


Stage Storage Data – to develop the stage storage curve, the areas at normal water (el. 743 assumed) and at elev. 750 will be determined from the USGS Southbridge Quad and averaged to compute the volume. Stage storage is assumed linear.

Area @ El. 743 = 1,237,000 sf

Area @ El. 750 = 1,758,000 sf

∴ Volume @ El. 750 = [(1,237,000 + 1,758,000) ÷ 2] × 7 = 10,482,500 cf



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SUBJECT Reservoir Nu 5 Analysis and Evaluation BY GMV CHKD BY JDP SHEET 5 OF 14

IV. Flood Routing: cont.

Routing of the SDF will be performed using the program for Muskingum Method Hydrograph Routing as contained in the text entitled "Hydrologic and Hydraulic Computations on Small Programmable Calculators" by Thomas E. Croley II.

$\Delta t = 20$ min.

$X = 0$ (reservoir routing

K = approximated as slope of line obtained by plotting storage vs. outflow

El. 743 to El. 744 $K = \frac{1,500,000}{194} \times \frac{1}{60} = 129$ up to O = 208 cfs

El. 744 to El. 745 $K = \frac{1,500,000}{459} \times \frac{1}{60} = 54$ up to O = 667 cfs

El. 745 to El. 746 $K = \frac{1,500,000}{834} \times \frac{1}{60} = 30$ up to O = 1501 cfs

NOTE: see following sheet for starting Outflow value

TIME	INFLOW	OUTFLOW		TIME	INFLOW	OUTFLOW
20 min.	92 cfs	↑ 7.1 cfs		400	805	886
40	184	26	K = 129 min.	420	750	832
60	276	55		440	695	777
80	368	94		460	640	722
100	460	140		480	585	667
120	552	192	↓	500	530	612
140	644	319	↑	520	475	557
160	736	435	K = 54 min.	540	420	502
180	828	543		560	365	447
200	920	647	↓	580	310	392
220	1012	807	↑	600	255	337
240	1104	932		620	200	282
260	1196	1040	K = 30 min.	640	145	227
280	1135	1101		660	90	172
300	1080	1104		680	35	117
320	1025	1078		700	0	67
340	970	1038		720	0	34
360	915	990		740	0	17
380	860	939		760	0	8

IV. Flood Routing: cont.

Starting Outflow Value for Routing –

$$I_1 + I_2 + \frac{2S_1}{\Delta t} - O_1 = \frac{2S_2}{\Delta t} + O_2$$

$$\therefore \; I_1 + I_2 = 92 \text{ cfs} = \frac{2S_2}{\Delta t} + O_2$$

@ El. 744 $\frac{2S_2}{\Delta t} + O_2 = 2708$ cfs, $O_2 = 208$ cfs

$$\therefore \frac{92}{2708} = \frac{O}{208} \Rightarrow O = 7.1 \text{ cfs}$$

Analysis of the test flood routing indicates that a peak outflow of 1104 cfs ± at a water surface elevation of 745.5 ± would occur as a result of an event producing a reservoir inflow equal to ½ of the Probable Maximum Flood. Because this condition indicates a freeboard of 2.5 ft. ±, and because any downstream impact due to failure would primarily be economic, the analysis of downstream impacts due to dam failure will be performed using the test flood.

V. Dam Failure Analysis:

To assess the downstream impacts due to dam failure, it will be *assumed that 40% of the mid-height embankment length will breach as a result of the test flood (½ PMF). NOTE: Calculations indicate that the full PMF will not overtop the dam

Mid-Height Length = 700 ft.

Assume Breach Width W_B = 40% of Length at Mid Height

$\therefore W_B = 0.40 \times 700 = 280$ ft.

WS elevation = 745.5 (from Test Flood Routing)

Downstream Elevation = 715 ± (From 1936 Contract Drawings)

$\therefore Y_o = 745.5 - 715 = 30.5$ ft.

Peak Failure Outflow $Q_{P_1} = \frac{8}{27} W_b \sqrt{g} Y_o^{3/2}$

$$\therefore Q_{P_1} = \frac{8}{27} \times 280 \times \sqrt{32.2} \times (30.5)^{3/2} = 79{,}298 \text{ cfs}$$

SAY $Q_{P_1} = 79{,}300$ cfs

* Assumption based upon U.S. COE Guidelines

VI. Downstream Dam Failure Analysis:

Following the breaching of the No. 5 Reservoir dam, the failure outflow would travel overland, approximately 600 ft. in a northerly direction, to No. 4 Reservoir. Stage discharge and stage storage curves for No. 4 Reservoir are developed with the aid of information contained in the Phase I Report for No. 4 Reservoir prepared by Metcalf & Eddy Inc. (Apr. 1978). Routing will be performed assuming that the initial water surface elevation in No. 4 Reservoir is 708.5 (Top of Dam)

Stage Storage Data —

Spillway (w/o flashboards)

Pond El.	706	707	708	708.5	709	710	711	712	713	714	715	720	725
H	1	2	3	3.5	4	5	6	7	8	9	10	15	20
C_d	0.655	0.705	0.755	0.780	0.805	0.855	0.905	0.955	1.01	1.06	1.11	1.36	1.61
Q_s	163	496	976	1271	1662	2380	3312	4404	5662	7093	8701	19,661	35,745

B_s MLE →

Low Level Outlet

Pond El.	705	708.5	709	710	711	712	713	714	715	720	725
H	16.5	22.0	22.5	23.5	24.5	25.5	26.5	27.5	28.5	33.5	38.5
G	47.6	51.9	52.5	53.7	54.8	55.9	57.0	58.1	59.1	64.1	68.7

B_L MLE →

Flow Over Crest

Pond El.	709	710	711	712	713	714	715	720	725
H	0.3	1.3	2.3	3.3	4.3	5.3	6.3	11.3	16.3
G	100	907	2135	3669	5457	7467	9677	23,247	40,275

B_c MLE →

Total Discharge

Pond El.	705	706	707	708	709	710	711	712	713	714	715	720	725
G	48	212	546	1027	1755	3341	5502	8129	11,176	14,612	18,437	42,912	76,689

Stage Storage Data — developed from contours on USGS Southwick, Mass. Quad

Area @ El. 708.5 = 63.8 Acres (assume vertical reservoir sides up to top of dam)

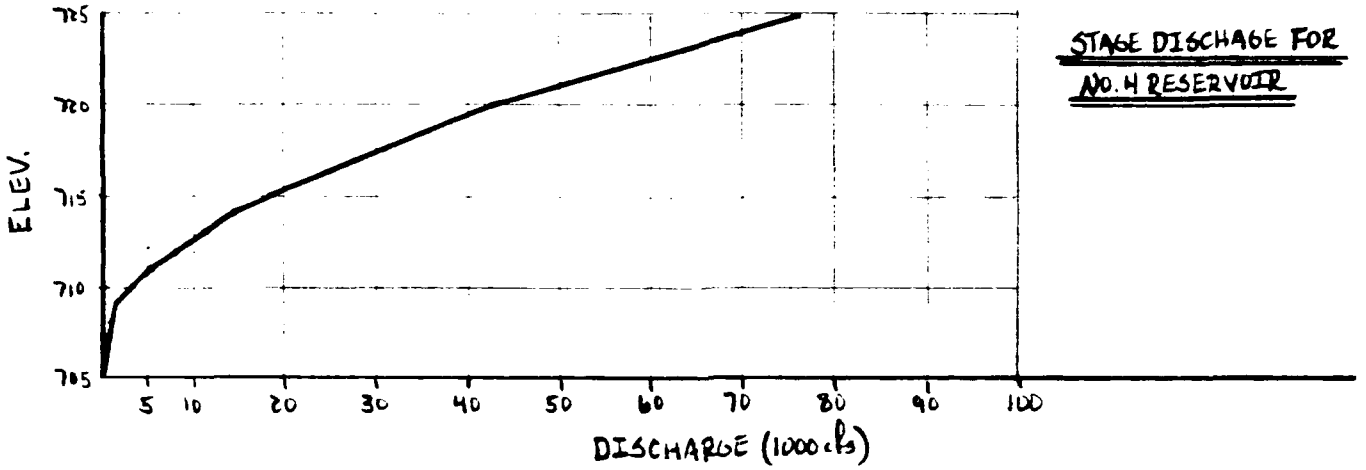
Area @ El. 710 = 81.7 Acres

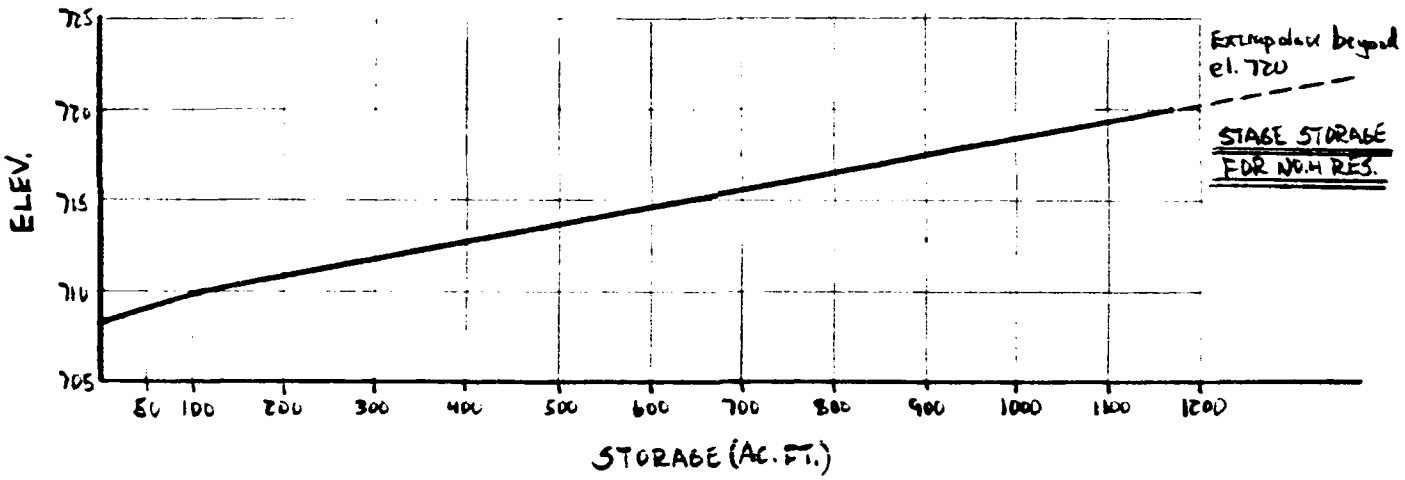
Area @ El. 720 = 130.5 Acres

$\therefore$ Vol. @ 710 $= \frac{63.8+81.7}{2} \times 1.5 = 109$ Ac. Ft.

$\therefore$ Vol. @ 720 $= \left(\frac{81.7+130.5}{2} \times 10\right) + 109 = 1170$ Ac. Ft.

VI. Downstream Dam Failure Analysis (cont.)





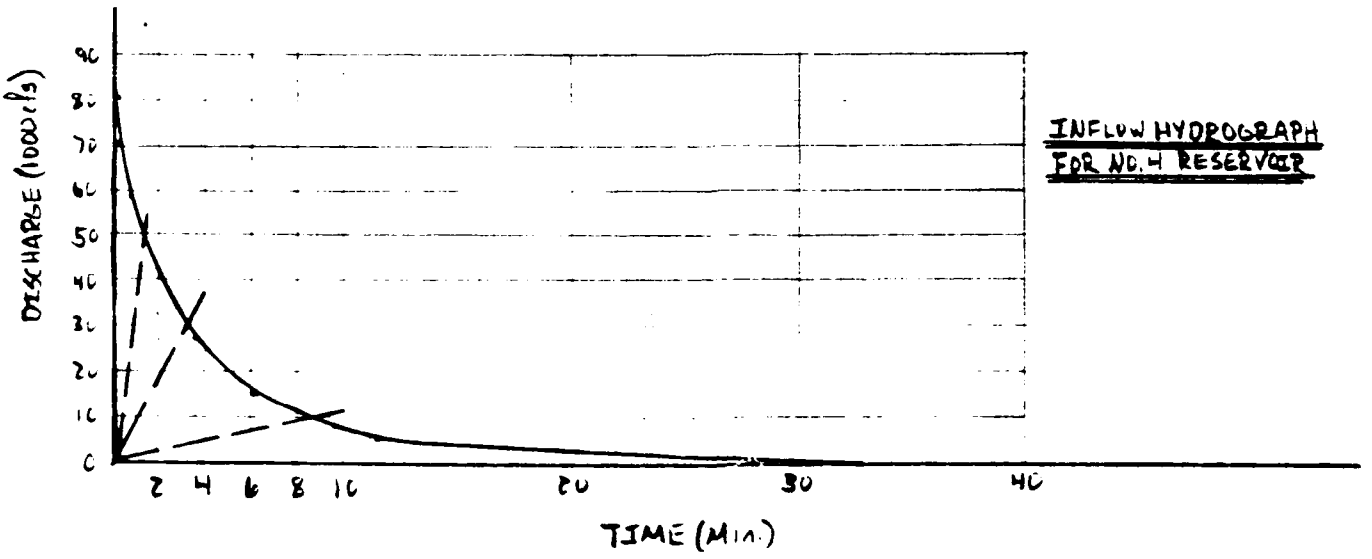
Total Inflow to No. 4 Reservoir = Q_p (from No. 5) + Spillway Flow (from No. 5)
= 79,298 + 1104 = 80,402 cfs SAY 80,400 cfs

Total Storage in Reservoir No. 5 at Time of Failure = Spillway Crest Stor. + Surcharge Stor.
Spillway Crest Storage = 410 Ac. Ft.
Surcharge Storage = 86 Ac. Ft. (el 745.5) − 33 Ac. Ft. (el. 744)
∴ Total Storage = 410 + (86 − 33) = 463 Ac. Ft.

VI. Downstream Dam Failure Analysis: cont.

Develop inflow hydrograph for No. 4 Reservoir based upon outflow through breach in No. 5 Reservoir.

ELEV.	Q_o	S	ΔTIME	TOTAL TIME
745.5	80,400 cfs	463 Ac. Ft.		
	$\bar{Q}$ = 79,105	ΔS = 8	0.1 Min.	0.1 Min.
745	77,810 cfs	455 Ac. Ft.		
	$\bar{Q}$ = 68,330	ΔS = 75	0.8	0.9
740	58,850 cfs	380 Ac. Ft.		
	$\bar{Q}$ = 50,480	ΔS = 76	1.1	2.0
735	42,110 cfs	304 Ac. Ft.		
	$\bar{Q}$ = 34,730	ΔS = 76	1.6	3.6
730	27,350 cfs	228 Ac. Ft.		
	$\bar{Q}$ = 21,120	ΔS = 76	2.6	6.2
725	14,890 cfs	152 Ac. Ft.		
	$\bar{Q}$ = 10,075	ΔS = 76	5.5	11.7
720	5,260 cfs	76 Ac. Ft.		
	$\bar{Q}$ = 2,630	ΔS = 76	21.0	32.7
715	0 cfs	0 Ac. Ft.		



INFLOW HYDROGRAPH FOR NO. 4 RESERVOIR

VI. Downstream Dam Failure Analysis: cont.

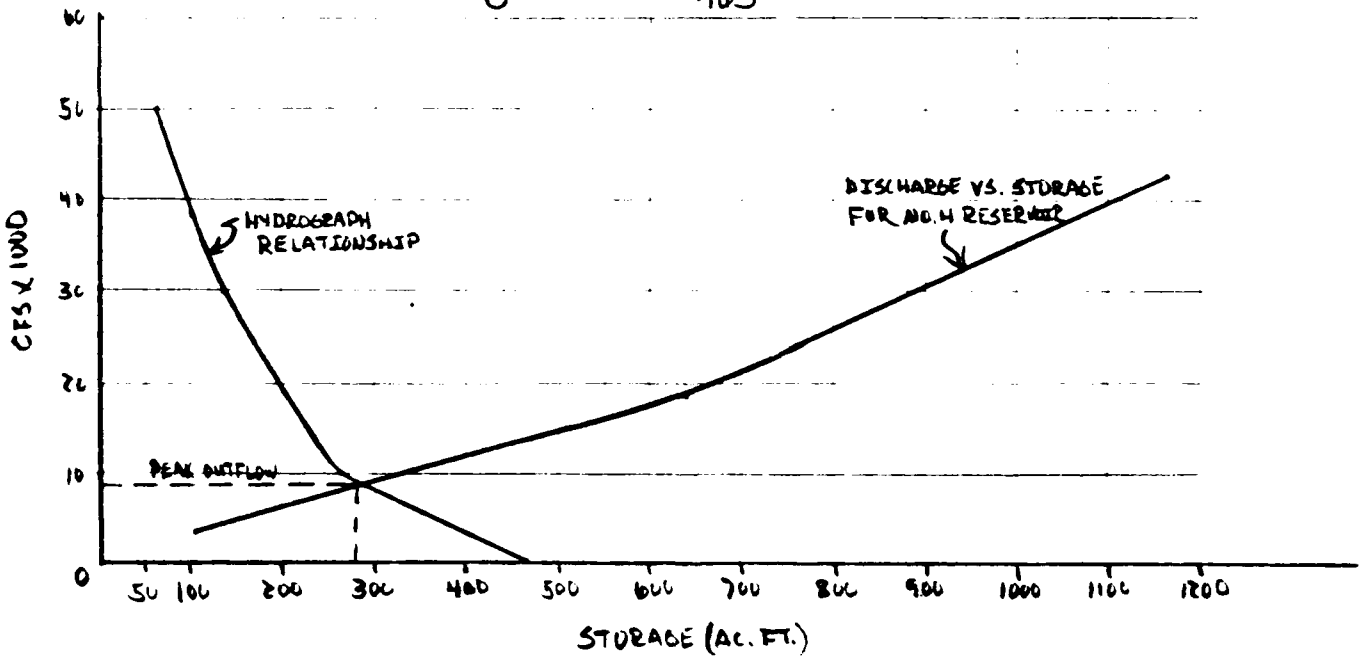
Route failure outflow through No. 4 Reservoir by plotting Discharge vs. Storage from No. 4 Reservoir and Outflow vs. Storage from No. 5 Reservoir.

FROM STAGE DISCHARGE AND STAGE STORAGE CURVES FOR NO. 4 RESERVOIR —

OUTFLOW	ELEV.	STORAGE
42,912 cfs	720	1170 Ac. Ft.
18,437	715	640
3,341	710	109

HYDROGRAPH RELATIONSHIP —

OUTFLOW	STORAGE
50,000 cfs	62 Ac. Ft.
30,000	139
10,000	264
0	463



Peak Outflow = 8800 cfs ±

∴ Elev. = 712.2 ± ⇒ Dam Overtopped by 3.7 ft. ±

Outflow travels to No. 3 Reservoir 500 ft. ± downstream (assume storage between No. 4 and No. 3 is negligible).

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VI. Downstream Dam Failure Analysis: cont.

Develop stage discharge and stage storage data for No. 3 Reservoir using information contained in the Phase I Report prepared by Camp, Dresser, & McKee, Inc. (Sept. 1979).

E-EV	Q_s	Q_{R1}	Q_{R2}	Q_{L1}	Q_{L2}	Q_{TOTAL}
678	–	–	–	–	–	0 cfs
679	147 cfs	–	–	–	–	147
679.5	270	–	–	–	–	270
680.75	674	–	–	–	94 cfs	768
681.3	888	6 cfs	–	–	156	1050
681.5	971	15	118 cfs	–	191	1295
682	1188	43	776	238 cfs	267	2512
683	1660	233	2936	1240	442	6511
684	2182	358	5876	2668	644	11,728
685	2750	501	9426	4420	871	17,968
686	3360	658	13,495	6444	1119	25,076
687	4010	830	18,023	8707	1386	32,956
688	4696	1014	22,968	11,186	1673	41,537
689	5418	1210	28,298	13,864	1976	50,766
690	6173	1417	33,986	16,728	2297	60,601
691	6961	1634	40,011	19,765	2632	71,003
692	7779	1862	46,355	22,966	2983	81,945
700	15,324	3784	107,098	53,711	6265	186,182

BY CDM

Storage Data from CDM Report –

Storage @ El. 680 ≈ 310 Ac. Ft.

Storage @ El. 690 = 622 Ac. Ft.

Assume water surface at crest of dam (elev. 681.5±) at time when failure outflow from No. 4 Reservoir reaches No. 3. ∴ Assume volume at 681.5 = 0, volume @ 690 = 265 Ac. Ft.

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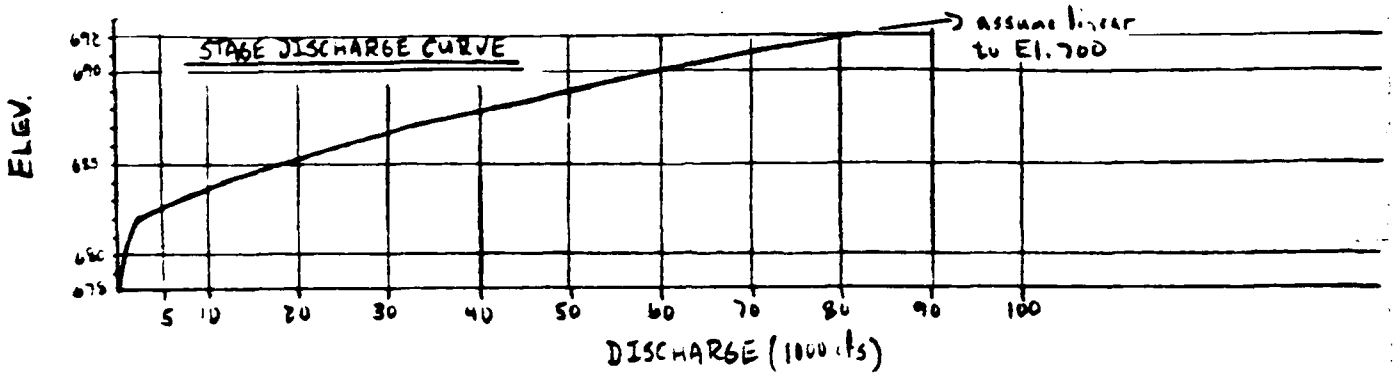
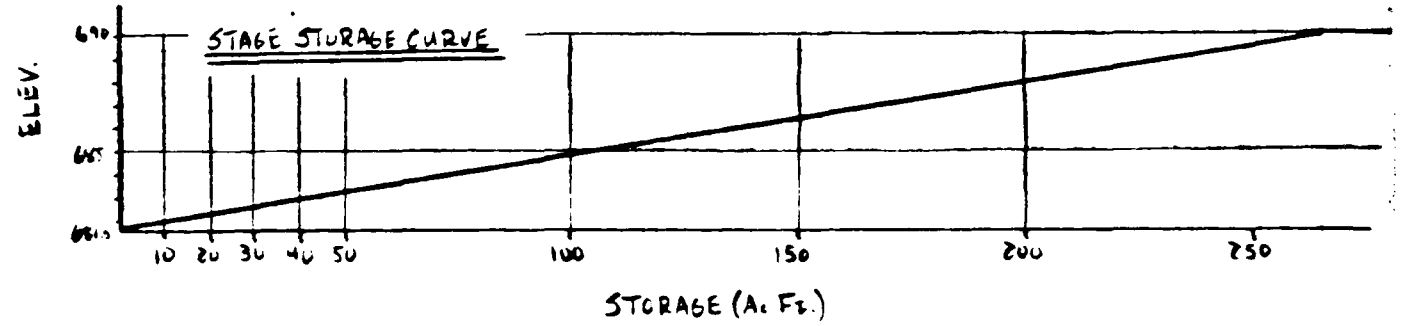
VI. Downstream Dam Failure Analysis: cont.



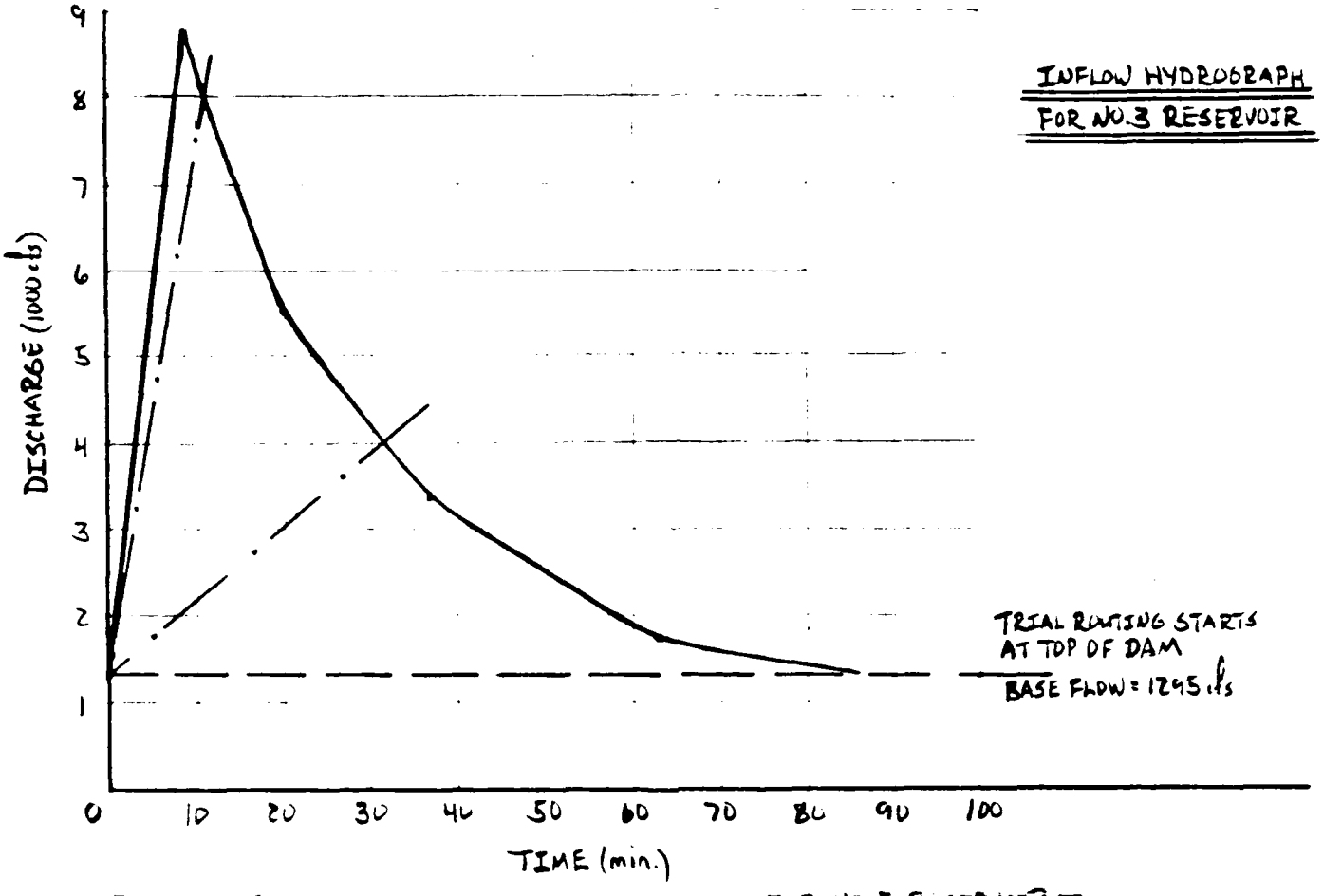


Develop Inflow Hydrograph for No. 3 Reservoir by using peak from outflow hydrograph for Reservoir No. 4 and time to drain the surcharge storage from No. 4 Reservoir (as determined below).

ELEV.	Q_o	S	ΔTime	Total Time
712.2	8800 cfs	342 Ac. Ft.		
	$\bar{Q}$ = 8465	ΔS = 18	1.5 min.	1.5 min.
712	8129	324		
	$\bar{Q}$ = 6816	ΔS = 92	9.8	11.3
711	5502	232		
	$\bar{Q}$ = 4422	ΔS = 93	15.3	26.6
710	3341	139		
	$\bar{Q}$ = 2548	ΔS = 92	26.2	52.9
709	1755	47		
	$\bar{Q}$ = 1573	ΔS = 47	21.7	74.6
708.5	1391	0		

NOTE: Additional time required to drain down to spillway level neglected

VI. Downstream Dam Failure Analysis: cont.



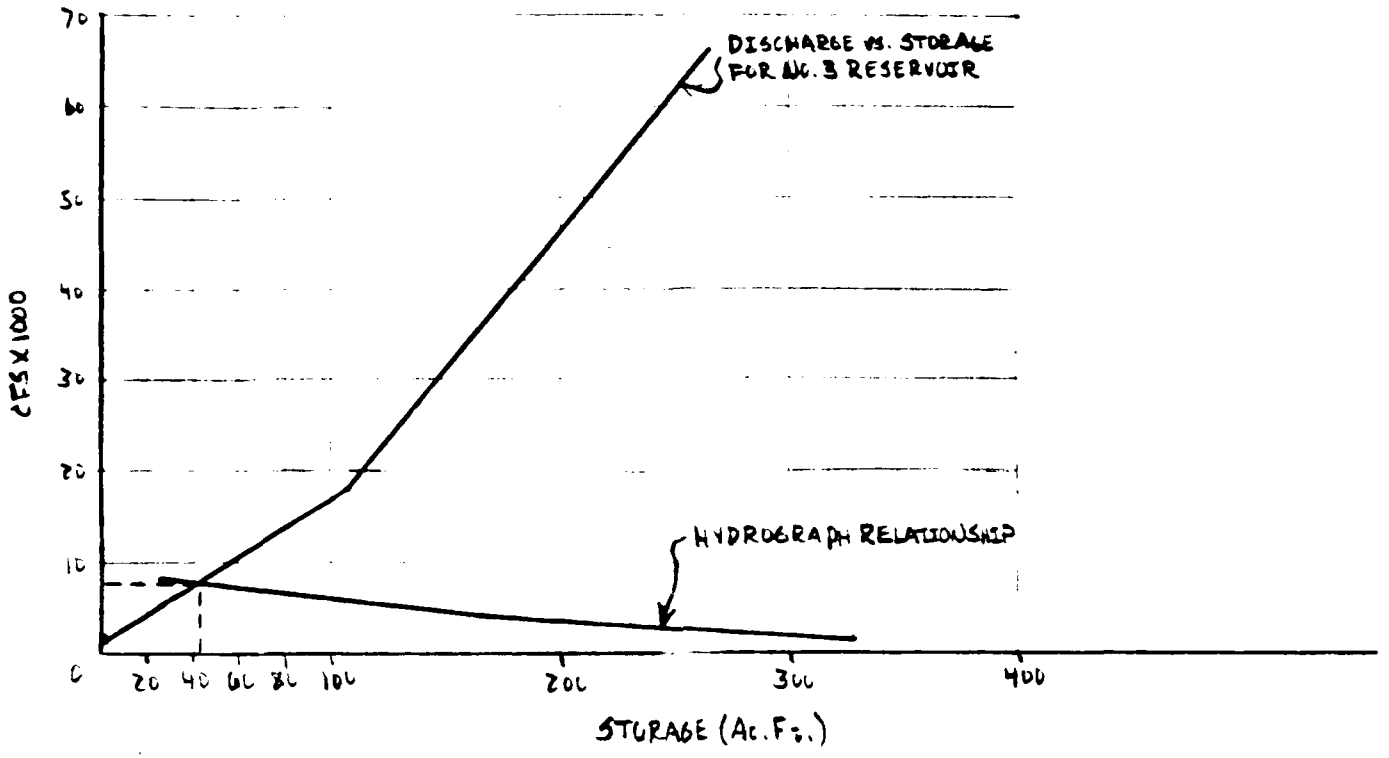
FROM STAGE DISCHARGE AND STAGE STORAGE CURVES FOR NO. 3 RESERVOIR —

OUTFLOW	ELEV.	STORAGE
60,601 cfs	690	265 Ac. Ft.
17,968	685	109
1,295	681.5	0

HYDROGRAPH RELATIONSHIP —

OUTFLOW	STORAGE
8000 cfs	27 Ac. Ft.
4000	165
1295	362

VI. Downstream Dam Failure Analysis: cont.



Peak Outflow = 7500 cfs ±

∴ Elev. = 683.2 ± ⇒ Dam Overtopped by 1.7 ft. ±

Approximately 7000 ft. downstream of No 3 Reservoir, the outflow reaches the Quinebaug River at the Westville Dam. Using the typical section shown for Reach 1 in the Phase I Report for No. 3 Reservoir (prepared by Camp Dresser & McKee), and assuming channel storage to be negligible, the average depth of flow downstream of No 3 Reservoir would be 5.8 ft. ± due to the peak failure outflow from No. 5 Reservoir. Examination of the information contained in the report for No. 3 Reservoir indicates that this depth would not cause serious flooding downstream.

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

NOT AVAILABLE AT THIS TIME

END

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