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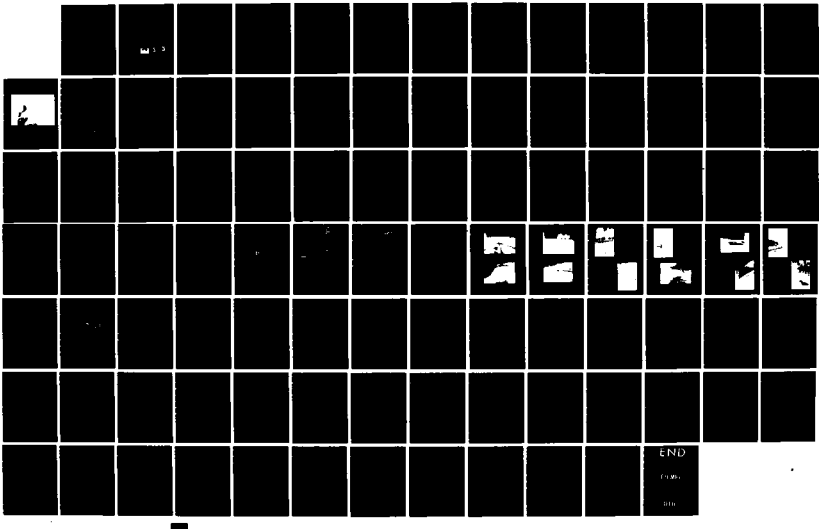
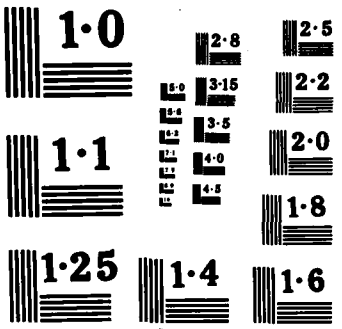




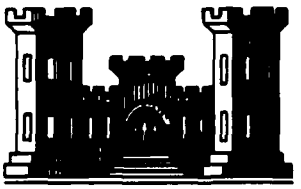
BLACKSTONE RIVER BASIN
LEICESTER, MASSACHUSETTS

KETTLE BROOK RESERVOIR No 3 DAM

MA 00978

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM



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

JUNE, 1981

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

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Blackstone River Basin
Leicester, Massachusetts
Kettle Brook

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

The dam is an earthen embankment structure with a masonry core wall. It is 370 ft. long and has a hydraulic height of 32.5 ft. The dam is classified as small in size with a high hazard potential. The dam is co nsidered to be in fair condition. The potential for hazard as a result of a breach is such that the breach may result in the loss of more than a few lives.

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

REPLY TO
ATTENTION OF:

AUG 18 1981

NEDED

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

Dear Governor King:

Inclosed is a copy of the Kettle Brook Reservoir No. 3 Dam (MA-00978) Phase I Inspection Report, prepared under the National Program for Inspection of Non-Federal Dams. The report is based upon a visual inspection, a review of past performance, and a preliminary hydrological analysis.

The preliminary hydrologic analysis has indicated that the spillway capacity for the Kettle Brook Reservoir No. 3 Dam would likely be exceeded by floods greater than 37 percent of the Probable Maximum Flood (PMF). Our screening criteria specifies that a dam classified as high hazard with a spillway capacity insufficient to discharge fifty percent of the PMF be judged as having a seriously inadequate spillway. As a result this dam is assessed as unsafe, non-emergency until more detailed studies prove otherwise or corrective measures are completed.

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

We recommend that within twelve months from the date of this report the owner of the dam engage the services of a qualified registered engineer to determine further the potential of overtopping the dam and the need for and the means to increase project discharge capacity. Based on this determination, appropriate remedial mitigating measures should be designed and completed within 24 months of this date of notification. In the interim a detailed emergency operation plan and warning system should be promptly developed and round-the-clock surveillance should be provided during periods of heavy precipitation or high project discharge.

AUG 18 1981

NEDED
Honorable Edward J. King

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

Copies of this report have been forwarded to the Department of Environmental Quality Engineering and to the owner, City of Worcester, Water Operations, Worcester, 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,

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

...on land ...
...y as it ...

KETTLE BROOK RESERVOIR NO. 3 DAM

MA 00978

BLACKSTONE RIVER BASIN
LEICESTER, MASSACHUSETTS

PHASE I - INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM
PHASE I - INSPECTION REPORT
BRIEF ASSESSMENT

Identification No.:	MA 00978
Name of Dam:	Kettle Brook Reservoir No. 3
City:	Leicester
County and State:	Worcester County, Massachusetts
Stream:	Kettle Brook
Date of Inspection:	December 5, 1980

Kettle Brook Reservoir No. 3 Dam, owned and operated by the City of Worcester for the purpose of water supply, is located in Leicester, Massachusetts. The dam is an earthen embankment structure with a masonry core wall. It is 370 feet long and has a hydraulic height of 32.5 feet. The storage capacity is 680 acre-feet. The emergency spillway discharges to Kettle Brook and is located on the east side of the site.

As a result of the visual inspection and a review of available data, Kettle Brook Reservoir No. 3 Dam is considered to be in fair condition. Major concerns include: spalling, cracking, and heaving of the spillway channel floor; poor condition of the interior of the gate-house; trees growing between spillway structure and the left abutment; the low-level outlet being under pressure as it passes through the dam embankment; and the inability of the spillway to pass the test flood discharge.

The dam is classified as small in size and a high hazard structure in accordance with the recommended guidelines established by the Corps of Engineers. The test flood for this dam equals the Probable Maximum Flood (PMF). The test flood inflow was estimated to be 5,230 cubic feet per second (cfs) and resulted in an outflow discharge estimated to be 3,000 cfs, which would overtop the dam crest by about 1.5 feet. The maximum spillway capacity with the water level at the dam crest was estimated to be 1,100 cfs, which is about 37 percent of the test flood discharge. A major breach to the dam would increase the stage along the immediate downstream channel of Kettle Brook to approximately 7 feet. Such a breach would cause Marshall Street, Earle Street, Mulberry Road, Waite Road, Chapel Street (twice), Kettle Brook Reservoir No. 1 and No. 2 Dams, and the dam at City Pond to be overtopped. It is estimated that

the Worcester Spinning Company just downstream of City Pond would be inundated by more than 15 feet of water. The potential for hazard as a result of a breach is such that the breach may result in the loss of more than a few lives.

It is recommended that the City of Worcester engage a qualified registered professional engineer to investigate the cause of the spillway channel floor distress and the structural integrity of the gatehouse interior and the bridge over the spillway. The engineer should specify and oversee procedures for the removal of trees in the embankment and for filling the animal burrow on the downstream slope. The engineer should investigate and design outlet controls for the low-level outlet on the upstream side of the embankment to alleviate pressure in the pipe as it passes through the dam and should perform a detailed hydrologic and hydraulic investigation to assess the potential of overtopping the dam and the need for and the means to increase project discharge capacity. A visual inspection should be made once a month and a comprehensive technical investigation made once a year. A surveillance program should be established for use during and after a heavy rainfall, and a downstream warning program developed.

The recommendation and remedial measures are described in Section 7 and should be addressed by the owner within one year after receipt of this Phase I Inspection Report.

Howard Shaevitz, P.E.
Project Manager
M.P.E. No. 28447

SCHOENFELD ASSOCIATES, INC.
Boston, Massachusetts

This Phase I Inspection Report on **Kettle Brook Reservoir No. 3 (MA-00978)** 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.

ARAMAST MAHTESIAN, MEMBER
Geotechnical Engineering Branch
Engineering Division

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

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

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

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

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

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

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

The Phase I Investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings, and other items which may be needed to minimize trespassing 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.

KETTLE BROOK RESERVOIR NO. 3 DAM

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APPENDIX E - INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

SECTION 5
EVALUATION OF HYDROLOGIC/HYDRAULIC FEATURES

5.1 General

Kettle Brook Reservoir No. 3 Dam is an earth embankment structure having a masonry core wall. According to the design drawing, the dam is 370 feet long and has a maximum structural height of 38.5 feet. The crest, downstream slope, and upper portion of the upstream embankment slope is covered with grass. The remainder of the upstream face is riprapped. The emergency spillway has a length of 34 feet at the weir and is located on the east side of the site. The spillway discharges to Kettle Brook. The normal outlet is a 30-inch pipe laid in masonry in the original earth.

The dam impounds Kettle Brook Reservoir No. 3, which forms a portion of the water supply system for the greater Worcester area.

5.2 Design Data

No hydrological or hydraulic design data were disclosed.

5.3 Experience Data

Daily readings of the water surface elevations for the period of operation are maintained by the Supervisor, Water Supply, City of Worcester. The records indicate that the highest surface elevation was 1,041.4 and occurred on August 19, 1955.

5.4 Test Flood Analysis

Due to the absence of detailed design information, the hydrologic evaluation was performed utilizing data gathered during the field inspection, watershed size, and an estimated test flood equal to the Probable Maximum Flood (PMF). The full PMF test flood was selected because the dam falls on the upper end of the small size range. The drainage basin is essentially rolling. Using the appropriate Corps of Engineers guide curve, an inflow value of 2,050 cfs per square mile was obtained for the watershed.

SECTION 4
OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operational Procedures

a. General. The dam impounds water in Kettle Brook Reservoir No. 3, which is part of the water supply system for the City of Worcester.

The pool elevation is controlled by two hand-operated gate valves located within the gatehouse.

b. Description of Any Warning System in Effect. No written warning system or emergency preparedness system exists for the dam.

4.2 Maintenance Procedures

a. General. The City of Worcester, Water Operations, is responsible for maintenance of the dam. The grass on the crest, downstream slope, and upper portion of the upstream sloped is mowed and the area is visited daily. There are no established procedures or manuals.

b. Operating Facilities. No formal maintenance procedures for the operating facilities were disclosed.

4.3 Evaluation

The current operational and maintenance procedures appear adequate to insure that normal problems can be remedied within a reasonable period of time. The dam and appurtenant structures should be visually inspected once a month and a comprehensive technical inspection made once a year. The owner should also establish a surveillance program for use during and immediately after heavy rainfalls. A downstream warning program to follow in case of emergency should also be developed.

(3) One animal burrow on the downstream slope of the dam which could become a focus for seepage and piping if not properly backfilled.

(4) The low-level outlet being under pressure where it passes through the dam embankment.

(5) Trees growing between the spillway structure and the left abutment which could cause erosion problems if any of them blow over and damage the adjacent left training wall of the spillway.

Trees growing on the downstream slope of the dam are not considered to be a problem because of the flatness of the downstream slope and the distance (about 65 feet) from the crest of the dam.

c. Appurtenant Structures. The spillway is 43-foot long. The 260-foot long rollway has a concrete-lined surface and masonry training walls. Some of the masonry joints on the training walls need regrouting, but the spillway is structurally sound (Photo No. 6).

The gatehouse is a concrete structure with a masonry foundation. The structural condition of the gatehouse is fair (Photo No. 7).

A service bridge provides access to the gatehouse from the dam embankment. The bridge is of steel construction supported by an intermediate pier of concrete (Photo No. 8). It has a wooden deck with several rotted boards. The structural condition of the bridge is fair. A zone which is at least 25 feet wide on either side of the emergency spillway chute at the left abutment is maintained free of trees, brush and weeds.

It was not possible to inspect the interior of the gatehouse. However, the owner reported that the outlet works are frequently operated and are in good working condition.

d. Reservoir. No evidence of significant sedimentation in the reservoir was observed.

e. Downstream Channel. There is no downstream channel. The emergency spillway chute and the low-level outlet pipe both discharge directly into Holden Reservoir No. 2 (Photo Nos. 9-12).

3.2 Evaluation

On the basis of the visual inspection the overall condition of the dam is judged to be fair.

Some irregularity of the riprap on the upstream face of the dam and some cracking and deterioration of the slush grout between the riprap stones in the upper part of the riprap is evidence of deterioration of the riprap, which should be controlled to prevent erosion of the embankment fill.

The lack of grass cover in the wheel tracks on the crest of the dam increases the susceptibility of the crest to erosion in case the dam should be overtopped.

Minor softness on some of the lower parts of the downstream slope may be indicative of a seepage problem which could become worse and might possibly lead to a piping problem.

In general, the dam, abutments, and downstream toe areas appear to be well-maintained.

The structural condition of the dam is fair. The visual inspection did not reveal items of a significant nature that would lead to a less favorable assessment.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. The visual inspection of Kettle Brook Reservoir No. 3 Dam was conducted on December 5, 1980. The field inspection team consisted of personnel from Schoenfeld Associates, Inc., D. Baugh Associates, Inc., and Geotechnical Engineers, Inc. Inspection checklists, completed during the field site visit, are included in Appendix A.

At the time of the inspection the water level in the reservoir was approximately 9.6 feet below the elevation of the spillway crest.

The overall condition of the dam and its appurtenant structures is fair.

b. Dam. The dam is a masonry core, earth embankment structure. The crest, downstream slope, and upper portion of the upstream slope of the embankment are covered with grass which has been kept mowed and well-maintained (Photo No. 1). There is riprap on the upstream slope to about five feet below the crest to an undetermined elevation below the level of the water in the reservoir at the time of the inspection (Photo No. 2). The riprap and the downstream face are in good condition even though there is some minor local displacement. It must be noted, however, that at the time of the inspection the pool elevation was extremely low. One 6-inch animal burrow was observed on the downstream slope near the center of the dam and 5 feet below the crest.

There was no evidence of seepage, softness, or vegetation associated with wetness anywhere on the downstream slope or in the area adjacent to the downstream toe of the dam.

Several large evergreen trees are growing around the gatehouse which is located on the downstream slope left of the center of the dam (Photo No. 3). These trees are not considered to be a problem because of the flatness of the downstream slope and the distance from the crest of the dam to the gatehouse. (The ground elevation at the gatehouse is only about 12 feet lower than the crest of the dam; the distance downstream from the dam to the gatehouse is about 65 feet.)

Both abutments of the dam appear to consist of soil and are generally well-maintained and free of trees and brush, except for a clump of cedar trees which are growing between the spillway structure and the left abutment.

SECTION 2
ENGINEERING DATA

2.1 Design

A design drawing for Kettle Brook Reservoir No. 3 Dam was prepared by the Worcester County Engineering Department. This plan, dated October 3, 1902, was traced in 1936.

2.2 Construction

No construction records were available for use in evaluating the dam.

2.3 Operation

No engineering operation data were found.

2.4 Evaluation

a. Availability. The engineering data used in the preparation of this report are presented in Appendix B.

b. Adequacy. Available engineering data and design drawings are considered adequate for a Phase I investigation.

c. Validity. The field investigation indicated that the external features of the Kettle Brook Reservoir No. 3 Dam have not changed substantially from the design drawing of 1936.

i. Spillway

(1) Type - emergency

(2) Length of weir - 34 feet

(3) Crest elevation - 1040.0

(4) Gates - none

(5) U/S channel - Kettle Brook Reservoir No. 3; channel protected by rubble riprap

(6) D/S channel - the spillway is 34 feet wide at the weir and narrows to 12 feet wide over a distance of 253 feet while dropping in elevation from 1040.0 to 1012.0

(7) General - discharges to Kettle Brook

j. Regulating Outlet

(1) Invert - 1,014.0 feet upstream; 1,012.0 feet downstream

(2) Size - 30-inch concrete pipe, 300 feet long

(3) Description - the spillway is about 5 feet below the top of the dam and narrows from 34 feet at the weir to 12 feet at the end

(4) Control mechanism - two hand-operated gate valves in series and located within the gatehouse

(5) Other - none

(2) Flood control pool - N/A

(3) Spillway crest pool - 467

(4) Test flood pool - 760

(5) Top of dam - 680

f. Reservoir Surface (acres)

(1) Normal pool - 37

(2) Flood control pool - N/A

(3) Spillway crest pool - 37

(4) Test flood pool - 55

(5) Top of dam - 50

g. Dam

(1) Type - earthfill with core wall 2 feet thick at top (elevation 1,043.0), rubble paving on upstream face.

(2) Length - 370 feet

(3) Hydraulic height - 32.5 feet

(4) Top width - 20 feet

(5) Side slopes - upstream 2:1 H:V; downstream 1.5:1 H:V for a horizontal distance of approximately 6 feet measured from downstream edge of top of embankment; then 6:1 H:V

(6) Zoning - select material with a core wall and riprap on upstream face

(7) Impervious core - masonry core wall 2 feet thick at top (elev. 1,043) and 5 feet thick at base (elev. 1,007)

(8) Cutoff - two masonry cutoff walls on the upstream side of the core wall are indicated on a drawing obtained from the county

(9) Grout curtain - N/A

(10) Other - none

h. Diversion and Regulating Tunnel - N/A

(3) The emergency spillway capacity with the water surface elevation at the top of the dam (elevation 1044.5) is 1,100 cfs.

(4) The spillway capacity with the water surface at the test flood elevation (1046.0) is 1,100 cfs.

(5) The spillway capacity at normal pool elevation (1040.0) is not applicable since under normal pool conditions, no flow passes over the spillway.

(6) The total project discharge at the top of the dam was established to be 1,100 cfs. There are no provisions for flashboards.

(7) The total project discharge at the test flood elevation of 1046.0 is approximately 3,000 cfs.

c. Elevation (feet above NGVD)

(1) Streambed at centerline of dam - 1012.0

(2) Bottom of cutoff - 1,006 (estimated)

(3) Maximum tailwater - unknown

(4) Normal pool - 1,040

(5) Full flood control pool - N/A

(6) Emergency spillway crest - 1,040.0

(7) Design surcharge - unknown

(8) Test flood surcharge - 1,046.0

(9) Top of dam - 1,044.5

d. Reservoir (length in feet)

(1) Normal pool - 3,700 (estimated)

(2) Flood control pool - N/A

(3) Spillway crest pool - 3,700 (estimated)

(4) Test flood pool - 4,300 (estimated)

(5) Top of dam - 4,200 (estimated)

e. Storage (gross acre-feet)

(1) Normal pool - 467

No. 1 and No. 2 Dams, and the dam at City Pond. The Worcester Spinning Company plant just downstream of City Pond would be inundated by more than 15 feet of water. Loss of several lives would be possible.

e. Ownership. The dam is owned by the City of Worcester, Massachusetts.

f. Operator. The operation, maintenance, and safety of the dam is the responsibility of the City of Worcester, Water Operations. The Supervisor of Water Supply is Mr. Kenneth Starbard. His address is South Road, Holden, Massachusetts 01520. His telephone number is (617) 829-4811.

g. Purpose of Dam. The dam impounds water in Kettle Brook Reservoir No. 3, which is part of the water supply system for the City of Worcester.

h. Design and Construction History. Kettle Brook Reservoir No. 3 Dam was designed prior to 1900 by the Worcester County Engineering Department. The construction of this dam was completed in 1902.

i. Normal Operation Procedures. The pool elevation is controlled by two hand-operated gate valves located within the gatehouse. Water is supplied to the lower end of the system via a natural channel.

1.3 Pertinent Data

a. Drainage Area. The area tributary to Kettle Brook Reservoir No. 3 consists of 1,600 acres (2.5 square miles) of mountainous terrain. Of this, 1,100 acres (1.7 square miles) is regulated by Kettle Brook Reservoir No. 4 Dam, located approximately 2,500 feet upstream of Kettle Brook Reservoir No. 3 Dam. There is no development in the watershed. Maximum elevation is at about 1,395 feet; reservoir full elevation is at 1044.5 feet. The area around the reservoir is mostly wooded. There are no cottages or dwellings along the shoreline.

b. Discharge at Dam Site

(1) Outlet works for Kettle Brook Reservoir No. 3 Dam consist of a 34-foot long emergency spillway and a 30-inch outlet pipe. The invert of the outlet is at 1012.0 feet. Maximum discharge of the pipe when the reservoir is at the top of the dam (elevation 1044.5) is about 140 cfs. This flow is less than 5 percent of the test flow and is not considered significant in relation to the surcharge in the reservoir. It was not used in the analysis. The spillway has a crest at elevation 1040.0. When the water surface is at the top of dam (elevation 1044.5), the emergency spillway will have a capacity of 1,100 cfs.

(2) Daily records of the water surface elevations have been maintained at the site. The maximum recorded elevation was 1041.4 on August 19, 1955.

b. Description of Dam and Appurtenances. Kettle Brook Reservoir No. 3 Dam is an earth embankment structure having a masonry core wall. Both abutments of the dam apparently consist of soil. According to the drawings obtained from the owner, the dam is 370 feet long and has a maximum structural height of 38.5 feet. The top width is 20 feet. The upstream face of the dam is riprapped to approximately five feet below the crest to an undetermined elevation below the level of the water in the reservoir. The crest, downstream slope, and upper portion of the upstream embankment slope are covered with grass. The drawing provided by the county shows an upstream slope of 1-1/2 horizontal to 1 vertical, with spoil placed on a 6 horizontal to 1 vertical against the downstream slope, made up of selected material.

Appurtenant structures include an emergency spillway which is 34 feet long and approximately 5 feet below the top of the dam. The channel narrows to 12 feet over a distance of 253 feet while dropping in elevation from 1040.0 to 1012.0. The floor of the spillway channel is concrete. Immediately downstream of the chute spillway is a low stone-masonry training wall on the right side of the downstream channel. There are weepholes at the bottom of the wall. A concrete archway spans the spillway at the spillway weir. A 30-inch low-level outlet pipe is laid in masonry in a trench in the original ground, with a masonry seepage collar around the pipe near its upstream end. A stone-masonry gatehouse is located over the low-level outlet and is approximately 65 feet downstream from the centerline of the dam. The ground elevation of the gatehouse is about 12 feet lower than the crest of the dam. Two gate valves in series control the flow through the low-level outlet. The location of the valves means that the low-level outlet through the dam is always under pressure.

Kettle Brook Reservoir No. 3 provides storage for the high service distribution system for the City of Worcester, Massachusetts. Water stored on the reservoir can be released to the lower part of the system only through natural channel flow to Reservoir No. 2 located downstream.

c. Size Classification. The dam is considered to be small in size because the hydraulic height is 32.5 feet and the storage is 680 acre-feet. This is in accordance with the Recommended Guidelines for Safety Inspections for Dams, which defines a small dam as having a hydraulic height of 25 to 40 feet and a storage of 50 to 1,000 acre-feet.

d. Hazard Classification. The potential for hazard posed by this dam is classified as high. This is in accordance with the Recommended Guidelines for Safety Inspection for Dams, which defines a high hazard structure as one which is located where failure may cause the loss to more than a few lives. A major breech to Kettle Brook Reservoir No. 3 Dam would result in the overtopping of Marshall Street, Earle Street, Mulberry Road, Waite Road, Chapel Street (twice), Kettle Brook Reservoir

NATIONAL DAM INSPECTION PROGRAM
PHASE I - INSPECTION REPORT
KETTLE BROOK RESERVOIR NO. 3 DAM

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. Schoenfeld Associates, Inc. has been retained by the New England Division to inspect and report on selected dams in the Commonwealth of Massachusetts. Authorization and notice to proceed were issued to Schoenfeld Associates, Inc. under a letter of October 30, 1980 from Colonel William E. Hodgson, Jr., Deputy Division Engineer. Contract No. DACW33-81-C-0010 has been assigned by the Corps of Engineers for this work.

b. Purpose

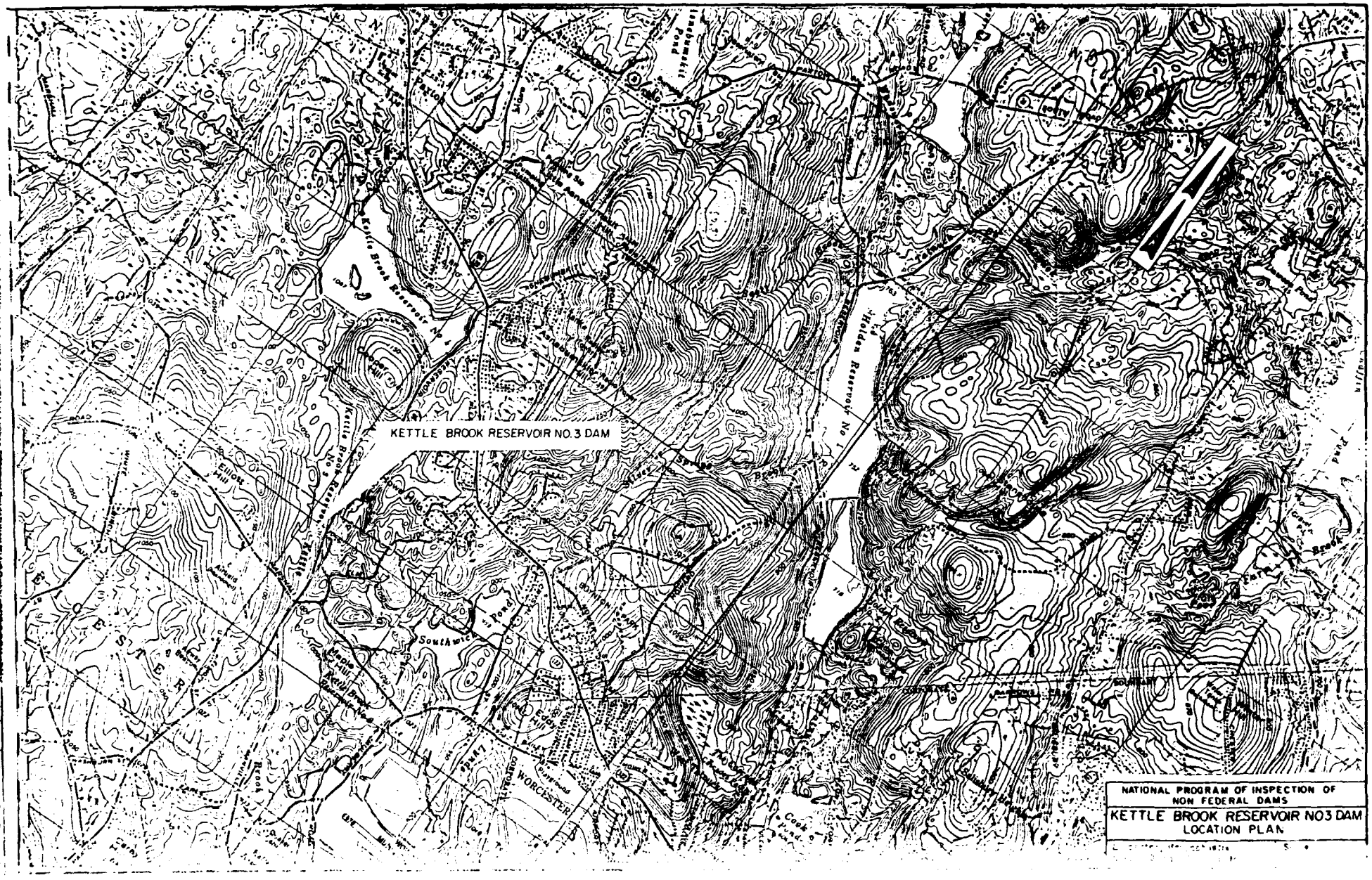
(1) To perform technical inspection and evaluation of nonfederal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by nonfederal interests.

(2) To encourage and prepare the states to initiate quickly effective dam safety programs for nonfederal dams.

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

1.2 Description of Project

a. Location. Kettle Brook Reservoir No. 3 Dam is located in the northwest portion of the town of Leicester, Massachusetts, and is situated on Kettle Brook approximately 1.3 miles upstream of Kettle Brook Reservoir No. 1 Dam. The emergency spillway discharges to Kettle Brook and is located approximately 2,200 feet upstream of the upper end of Kettle Brook Reservoir No. 2. The dam is shown on the U.S.G.S. quadrangle sheet for Paxton, Massachusetts. Its approximate coordinates are N42°-16'-54" and W71°-54'-30". The location of the dam is shown on the preceding page.


KETTLE BROOK RESERVOIR NO.3 DAM
NATIONAL PROGRAM OF INSPECTION OF NON FEDERAL DAMS
KETTLE BROOK RESERVOIR NO3 DAM
LOCATION PLAN

OVERVIEW PHOTOGRAPHY
KETTLE BROOK RESERVOIR NO. 3 DAM

Kettle Brook Reservoir No. 4 is located about 2,500 feet upstream of Kettle Brook Reservoir No. 3. Due to the size and location of Reservoir No. 4, the two reservoirs were assumed to fill at the same rate and during the same time period. Thus, they were considered as one reservoir to facilitate a simplified routing. A test flood inflow of 5,230 cfs was routed over the dam at Reservoir No. 3 in accordance with the Corps of Engineers procedure for Estimating Effect of Surcharge Storage on Maximum Probable Discharge. The reservoir water surface was assumed to be at elevation 1,040.0 prior to the flood routing. The project discharge was estimated to be 3,000 cfs. This analysis indicated that the dam embankment crest would be overtopped by approximately 1.5 feet. The maximum spillway capacity with the water level at the dam crest was estimated to be 1,100 cfs, which is 37 percent of the test flood discharge. The 34-foot long by 4.5 foot deep emergency spillway channel does not have adequate capacity to handle the test flood discharge. The capacity of the spillway channel was estimated to be approximately 1,100 cfs with consideration given to the concrete arch bridge span (see Appendix D, Page 3/33). The culvert capacity was estimated to be approximately 140 cfs. The flow through the culvert is less than 5 percent of the test flow and is not considered significant in relation to the surcharge in the reservoir. It was not used in the analysis.

5.5 Dam Failure Analysis

The impact of dam failure with the reservoir surface at the dam crest was assessed utilizing the "Rule of Thumb" Guidance for Estimating Downstream Dam Failure Hydrographs provided by the Corps of Engineers. The analysis covered a reach extending approximately 1.3 miles downstream to a point where the flow resulting from a breach in the dam would inundate the Worcester Spinning Company plant on Chapel Street with more than 10 feet of water. Based on this analysis, Kettle Brook Reservoir No. 3 Dam was classified as a high hazard.

Antecedent flow would be about 1,240 cfs, which is negligible as compared to the breach outflow of 15,000 cfs. Therefore, it is assumed that absolute stages equal the increase in water surface elevation due to breach.

A major breach to the dam would increase the stage along the immediate downstream channel of Kettle Brook to approximately 7 feet. Such a breach would cause the following streets to be overtopped: Marshall Street (7.8 feet), Earle Street (4.3 feet), Mulberry Road (2.8 feet), and Chapel Street (2.4 and 1.7 feet). The dam embankments at Kettle Brook Reservoir Nos. 1 and 2 would be overtopped by 2.0 and 2.4 feet, respectively. Loss of several lives is possible.

SECTION 6
EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observations

The general structural stability of the dam is fair as evidenced by the vertical, horizontal, and lateral alignment. In general, the dam appears to be well maintained and in fair condition. The spillway weir is in fair condition, as are the spillway training walls.

The main area of concern is the floor of the concrete spillway channel which contains extensive cracking and heaving which allow discharge from the spillway to infiltrate the downstream face. This has the potential to eventually undermine the dam if left uncorrected.

The following conditions observed during the visual inspection also could lead to long-term stability problems.

(1) One 6-inch animal burrow on the downstream slope of the dam could become a focus for seepage and piping if it is not properly backfilled.

(2) Trees growing between the spillway structure and the left abutment could cause erosion problems if any of them fall over and damage the adjacent left training wall of the spillway.

(3) The 30-inch low-level outlet is under pressure where it passes through the dam embankment when the water level is above the crown of the pipe. Exfiltration from this outlet to the material in the embankment could result in piping problems at some time.

Trees growing around the gatehouse on the downstream slope of the dam are not considered to be a problem because of the flatness of the downstream slope and the distance (about 65 feet) from the crest of the dam to the gatehouse.

6.2 Design and Construction Data

One drawing dated October 3, 1902, shows a plan and longitudinal section of the dam and one cross-section of the dam through the gatehouse and low-level outlet pipe. The information shown on the drawing appears to be generally consistent with the information obtained from the visual inspection.

The drawing indicates that the dam has a masonry core wall and that the embankment consists of "selected material" with an upstream slope of 2 horizontal to 1 vertical and a downstream slope of 1-1/2 horizontal to 1 vertical, with "spoil" placed on a 6 horizontal to 1 vertical slope against the downstream slope of the "selected material." The bottom of the core wall is supposed to be "carried into ledge or firm foundation."

The drawing shows that a 30-inch low-level outlet pipe is "laid in masonry" in a trench in the original ground and that there is a masonry seepage collar around the pipe near its upstream end.

6.3 Post-Construction Changes

No significant post-construction changes could be ascertained.

6.4 Seismic Stability

This dam is in Seismic Zone 2 and, in accordance with the Phase I guidelines, no seismic analysis is warranted.

SECTION 7
ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. After consideration of the available information, the results of the inspection, contact with the owner, and hydraulic/hydrologic computations, the general condition of Kettle Brook Reservoir No. 3 Dam is judged to be fair. The major factor in this rating is the extensive cracking and heaving of the spillway channel. Other conditions indicative of potential long-term problems include the following.

(1) One animal burrow on the downstream slope of the dam could become a focus for seepage and piping if it is not properly backfilled.

(2) Trees growing between the spillway structure and the left abutment could cause erosion problems if any of them blow over and damage the adjacent left training wall of the spillway.

(3) The location of the valves controlling flow through the low-level outlet means that the outlet through the dam is always under pressure.

(4) The spillway is inadequate to carry the test flood discharge.

Trees growing around the gatehouse on the downstream slope of the dam are not considered to be a problem because of the flatness of the downstream slope and the distance (about 65 feet) from the crest of the dam.

b. Adequacy of Information. The information obtained from the design drawing and the results of the visual inspection are adequate for the purposes of this Phase I study.

c. Urgency. The owner should implement the recommendations in 7.2 and 7.3 within one year after receipt of this Phase I report.

7.2 Recommendations

The following investigations should be carried out and needed corrections performed under the direction of a registered professional engineer qualified in the design and construction of dams:

(1) Determine the cause of spillway channel floor distress.

(2) Determine structural integrity of gatehouse interior.

(3) Perform a detailed hydrologic and hydraulic investigation to assess for the potential of overtopping the dam and the need for and the means to increase project discharge capacity.

(4) Specify and oversee procedures for removal of trees and their root systems from the embankment between the spillway and the left abutment and backfill with proper material.

(5) Investigate and design outlet controls for the low-level outlet on the upstream side of the dam to alleviate pressure in the pipe as it passes through the dam.

Any recommendations made by the engineer should be carried out by the owner.

7.3 Remedial Measures

a. Operating and Maintenance Procedures. The owner should:

(1) Specify and oversee procedures for filling the animal burrow on the downstream slope of the embankment.

(2) Repair any deterioration of the bridge over the spillway.

(3) Visually inspect the dam and appurtenant structures once a month.

(4) Engage a registered professional engineer qualified in the design and construction of dams to make a comprehensive technical inspection of the dam once a year.

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

7.4 Alternatives

There are no practical alternatives to the recommendations and remedial measures described in Section 7.3.

APPENDIX A

INSPECTION CHECK LIST

VISUAL INSPECTION CHECKLIST
PARTY ORGANIZATION

PROJECT Kettle Brook Reservoir No. 3 DATE Dec. 5, 1980

TIME 2:00

WEATHER Clear, Cold, Windy

W.S. ELEV. 1030.3 UPSTREAM
1012.1 DOWNSTREAM

PARTY:

1. Howard Shaevitz, Schoenfeld Assoc.
2. Peter Austin, D. Baugh Assoc.
3. Ronald Herschfeld, Geotechnical Eng.
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Hydrology/Hyraulics	Howard Shaevitz	
2.	Structural and Stability	Peter Austin	
3.	Soils and Geology	Ronald Herschfeld	
4.			
5.			
6.			
7.			
8.			
9.			
10.			

PERIODIC INSPECTION CHECKLIST

PROJECT Kettle Brook Reservoir No. 3 DATE Dec. 5, 1980

PROJECT FEATURE Dam Embankment NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	1045.0
Current Pool Elevation	1030.3
Maximum Impoundment to Date	1041.4 (August 19, 1955)
Surface Cracks	None observed
Pavement Condition	Not paved
Movement or Settlement of Crest	None observed
Lateral Movement	None observed
Vertical Alignment	Good
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Good
Indications of Movement of Structural Items on Slopes	None observed
Trespassing on Slopes	No evidence of trespassing observed
Sloughing or Erosion of Slopes or Abutments	None observed
Rock Slope Protection - Riprap Failures	Riprap in good condition
Unusual Movement or Cracking at or Near Toe	None observed
Unusual Embankment or Downstream Seepage	None observed
Piping or Boils	None observed
Foundation Drainage Features	None observed
Toe Drains	None observed
Instrumentation System	None observed
Vegetation	Grass which has been mowed

PERIODIC INSPECTION CHECKLIST

PROJECT Kettle Brook Reservoir No. 3 DATE Dec. 5, 1980

PROJECT FEATURE Dike Embankment NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
DIKE EMBANKMENT	No Dike
Crest Elevation	
Current Pool Elevation	
Maximum Impoundment to Date	
Surface Cracks	
Pavement Condition	
Movement or Settlement of Crest	
Lateral Movement	
Vertical Alignment	
Horizontal Alignment	
Condition at Abutment and at Concrete Structures	
Indications of Movement of Structural Items on Slopes	
Trespassing on Slopes	
Sloughing or Erosion of Slopes or Abutments	
Rock Slope Protection - Riprap Failures	
Unusual Movement or Cracking at or Near Toe	
Unusual Embankment or Downstream Seepage	
Piping or Boils	
Foundation Drainage Features	
Toe Drains	
Instrumentation System	
Vegetation	

PERIODIC INSPECTION CHECKLIST

PROJECT Kettle Brook Reservoir No. 3 DATE Dec. 5, 1980

PROJECT FEATURE Intake Channel NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channel	
Slope Conditions	Good
Bottom Conditions	Not visible beneath pond
Rock Slides or Falls	None
Log Boom	None
Debris	None
Condition of Concrete Lining	Not applicable
Drains or Weep Holes	Not applicable
b. Intake Structure	
Condition of Concrete	Not visible
Stop Logs and Slots	None

PERIODIC INSPECTION CHECKLIST

PROJECT Kettle Brook Reservoir No. 3 DATE Dec. 5, 1980

PROJECT FEATURE Control Tower NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - CONTROL TOWER	
a. Concrete and Structural	
General Condition	Exterior good; interior floor poor
Condition of Joints	Fair
Spalling	None
Visible Reinforcing	None
Rusting or Staining of Concrete	None
Any Seepage or Efflorescence	None observed
Joint Alignment	Good
Unusual Seepage or Leaks in Gate Chamber	None observed
Cracks	Floor cracked
Rusting or Corrosion of Steel	Rust
b. Mechanical and Electrical	Not applicable
Air Vents	
Float Wells	
Crane Hoist	
Elevator	
Hydraulic System	
Service Gates	
Emergency Gates	
Lightning Protection System	
Emergency Power System	
Wiring and Lighting System	

PERIODIC INSPECTION CHECKLIST

PROJECT Kettle Brook Reservoir No. 3 DATE Dec. 5, 1980

PROJECT FEATURE Transition & Conduit NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - TRANSITION AND CONDUIT	Unknown
General Condition of Concrete	
Rust or Staining on Concrete	
Spalling	
Erosion or Cavitation	
Cracking	
Alignment of Monoliths	
Alignment of Joints	
Numbering of Monoliths	

PERIODIC INSPECTION CHECKLIST

PROJECT Kettle Brook Reservoir No. 3 DATE Dec. 5, 1980

PROJECT FEATURE Outlet Structure NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	
General Condition of Concrete	Fair
Rust or Staining on Concrete	None
Spalling	None
Erosion or Cavitation	None observed
Visible Reinforcing	None
Any Seepage or Efflorescence	None observed
Condition at Joints	Fair
Drain Holes	Appear to be open, no water discharging
Channel	
Loose Rock or Trees Overhanging Channel	None
Condition of Discharge Channel	Good

PERIODIC INSPECTION CHECKLIST

PROJECT Kettle Brook Reservoir No. 3 DATE Dec. 5, 1980

PROJECT FEATURE Spillway Weir NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	
General Condition	Good
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	A few cedar trees to left bank
Floor of Approach Channel	Rock pavement
b. Weir and Training Walls	
General Condition of Concrete	Fair
Rust or Staining	None
Spalling	Minor
Any Visible Reinforcing	None
Any Seepage or Efflorescence	None observed
Drain Holes	None observed
c. Discharge Channel	
General Condition	Fair
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	None
Floor of Channel	Sand and gravel
Other Obstructions	None

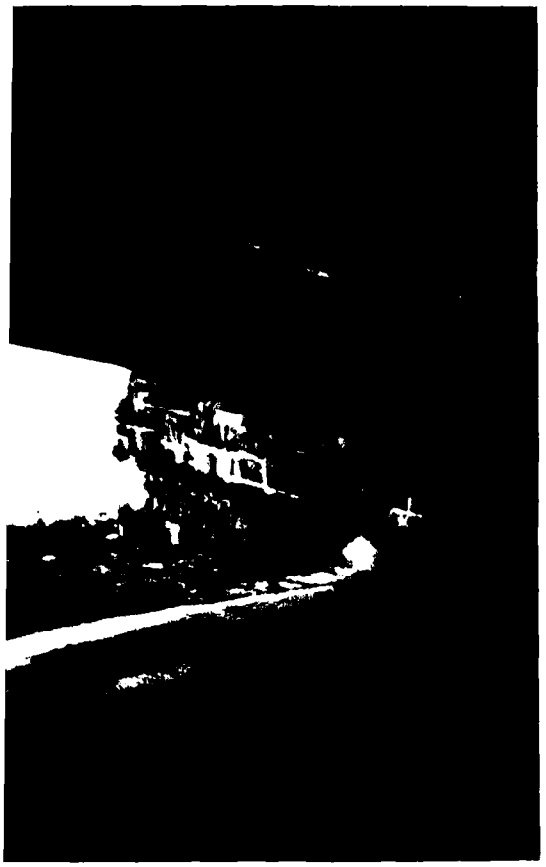


Photo No. 11 - Weir crest and underside of pedestrian bridge, with spalling of concrete arch-ring.

Photo No. 12 - Spillway and low-level outlet; looking upstream

Photo No. 9 - Pedestrian bridge and weir crest; looking upstream.

Photo No. 10 - Spalling of pedestrian bridge.

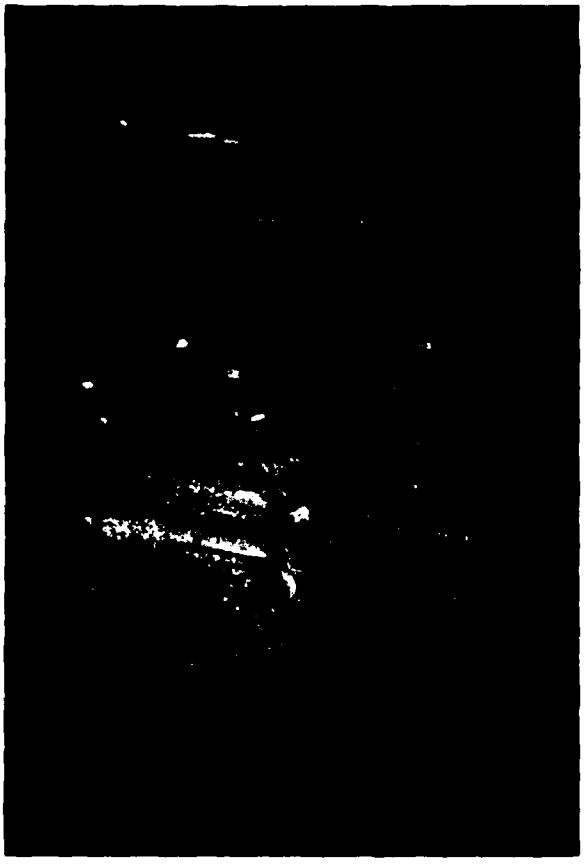


Photo No. 7 - Cracking in spillway floor.

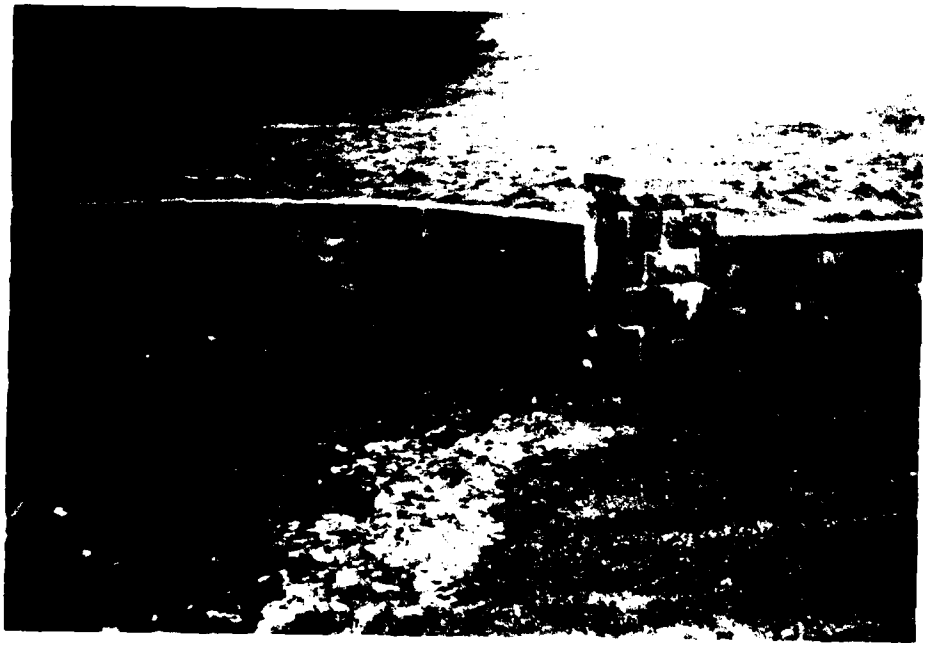


Photo No. 8 - Discharge end of low-level outlet.

Photo No. 5 - Cracking in spillway floor; gatehouse in background.

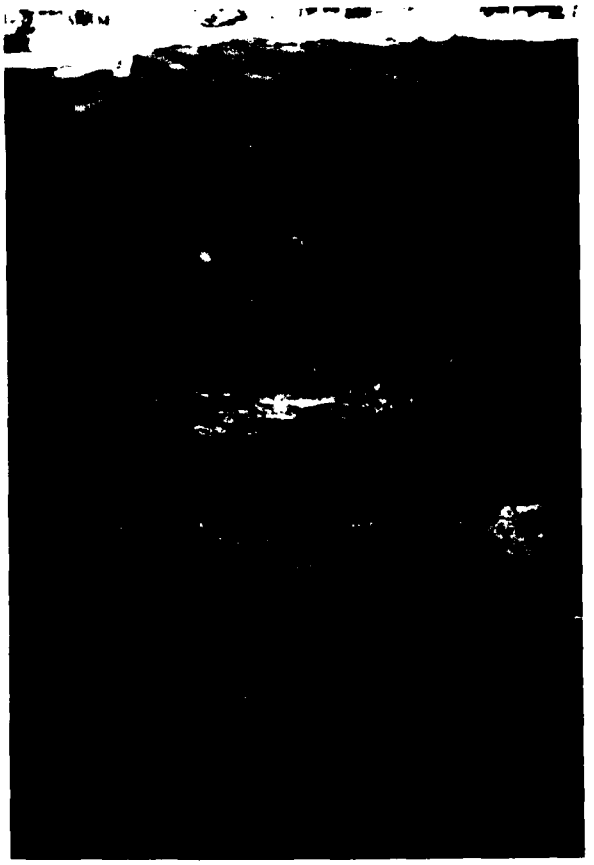


Photo No. 6 - Cracking in spillway floor; looking downstream.

Photo No. 3 - Dam and gatehouse viewed from downstream channel.

Photo No. 4 - Weir crest and pedestrian bridge; upstream face.

Photo No. 1 - Pedestrian bridge and embankment; looking to the west.

Photo No. 2 - Riprap on upstream slope of dam. Small terrace at elevation of spillway weir.

APPENDIX C

SELECTED PHOTOGRAPHS

(Index to Photographs is Found in Appendix B)

TOWN Leicester DAM NO. 25-24

LOCATION Reservoir Drive STREAM Kettle Brook

"Reservoir #3"

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by City of Worcester Place Water Dept. Use Water Supply

Inspected by W.O.L. Date Nov. 6, 1963

Type of Dam Earth and stone Condition Good

SPILLWAY

Flashboards in Place No boards Recent Repairs _____

Condition Good

Repairs Needed Small repairs are required on the downstream concrete channel floor

EMBANKMENT

Recent Repairs _____

Condition Good

Repairs Needed _____

GATES

Recent Repairs _____

Condition Good

Repairs Needed _____

LEAKS

How Serious _____

DATE: _____ County Engineer

TOWN Leicester DAM NO. 25-24

LOCATION Kettlebrook #3 STREAM

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by Place Use

Inspected by Reynolds Date

Type of Dam Condition

SPILLWAY

Flashboards in Place Recent Repairs

Condition Level 6' below crest

Repairs Needed

EMBANKMENT

Recent Repairs

Condition

Repairs Needed

GATES

Recent Repairs Open

Condition

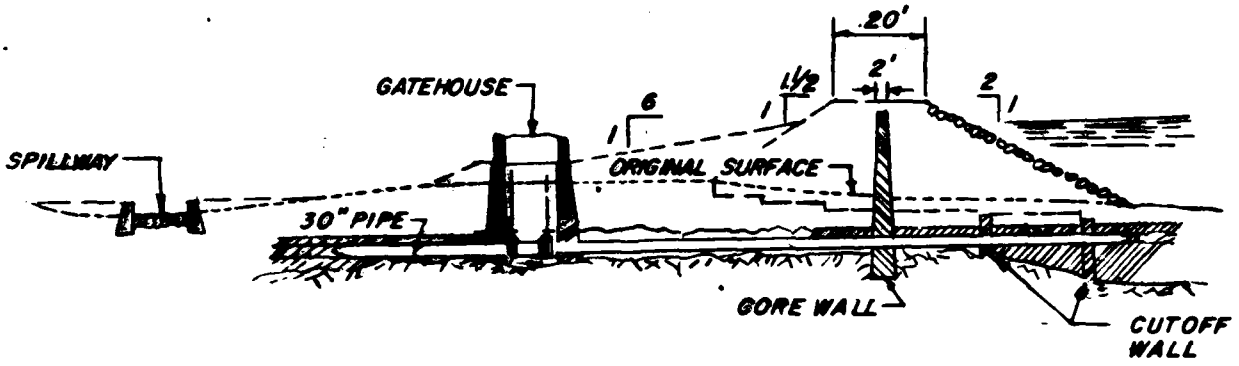
Repairs Needed

LEAKS

How Serious

DATE: March 1957

County Engineer

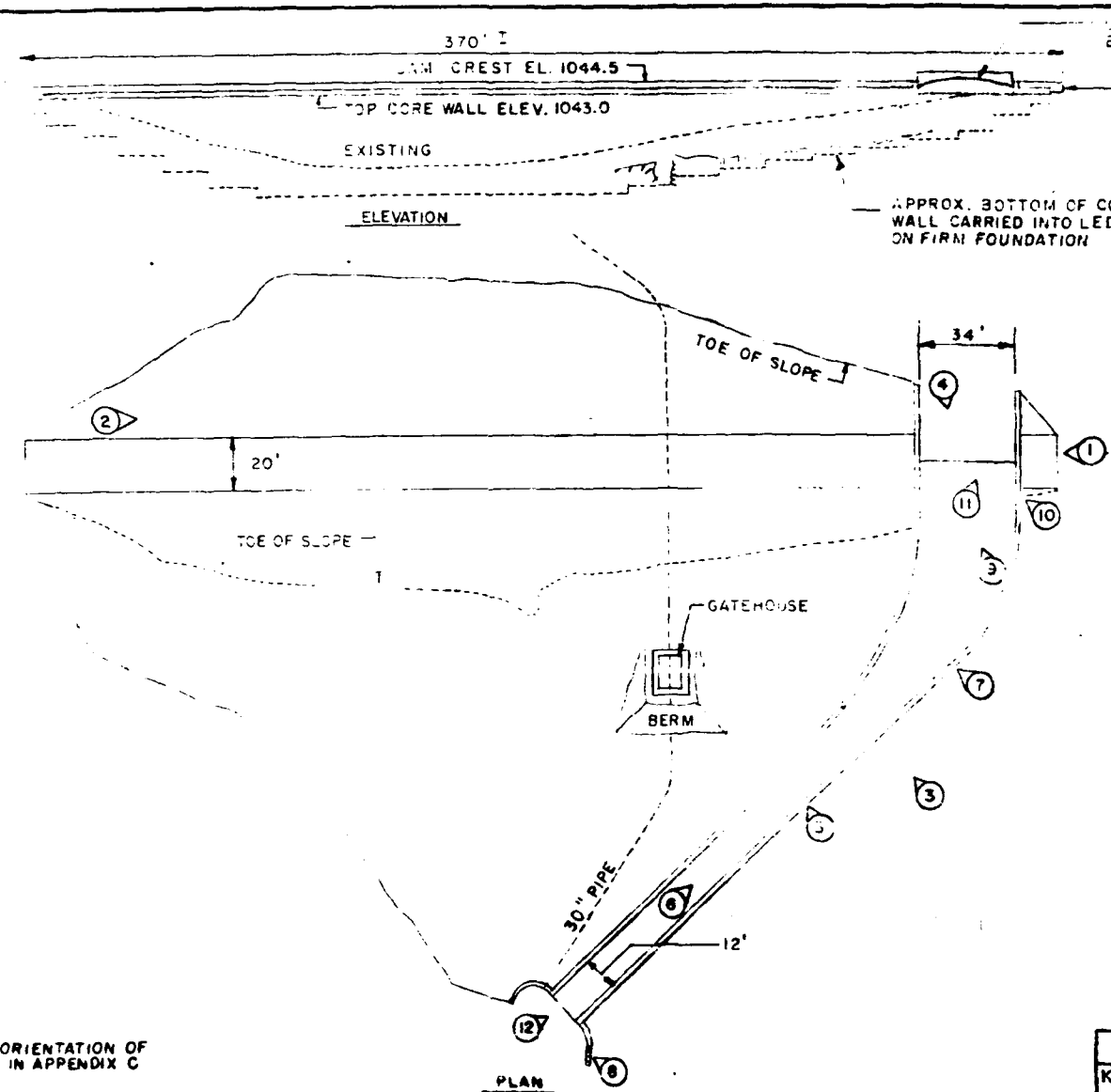


SECTION

NOTE

HATCHED AREAS SHOW MASONRY

NATIONAL PROGRAM OF INSPECTION OF NON FEDERAL DAMS	
KETTLE BROOK RESERVOIR NO.3 DAM SECTION	
Leicester, Massachusetts	Scale 1" = 40'



NATIONAL PROGRAM OF INSPECTION OF NON FEDERAL DAMS

KETTLE BROOK RESERVOIR NO.3 DAM
ELEVATION & PLAN

Available Engineering Data

A plan of the reservoir and dam was obtained from the City of Worcester, Water Operations, 16 East Worcester Street, Worcester, Massachusetts 01604. The drawing is dated October 3, 1902.

APPENDIX B

ENGINEERING DATA

PERIODIC INSPECTION CHECKLIST

PROJECT Kettle Brook Reservoir No. 3 DATE Dec. 5, 1980

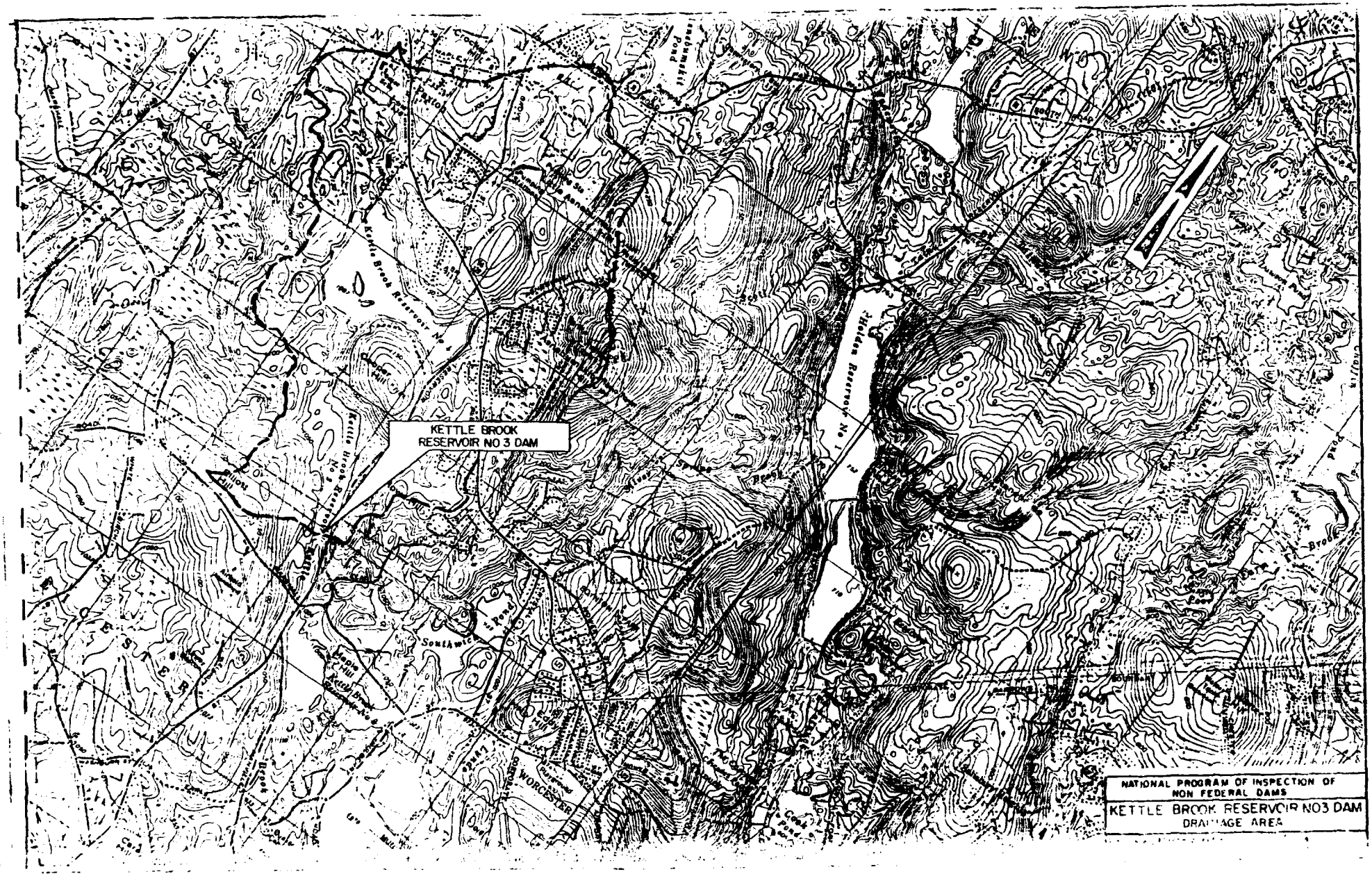
PROJECT FEATURE _____ NAME _____

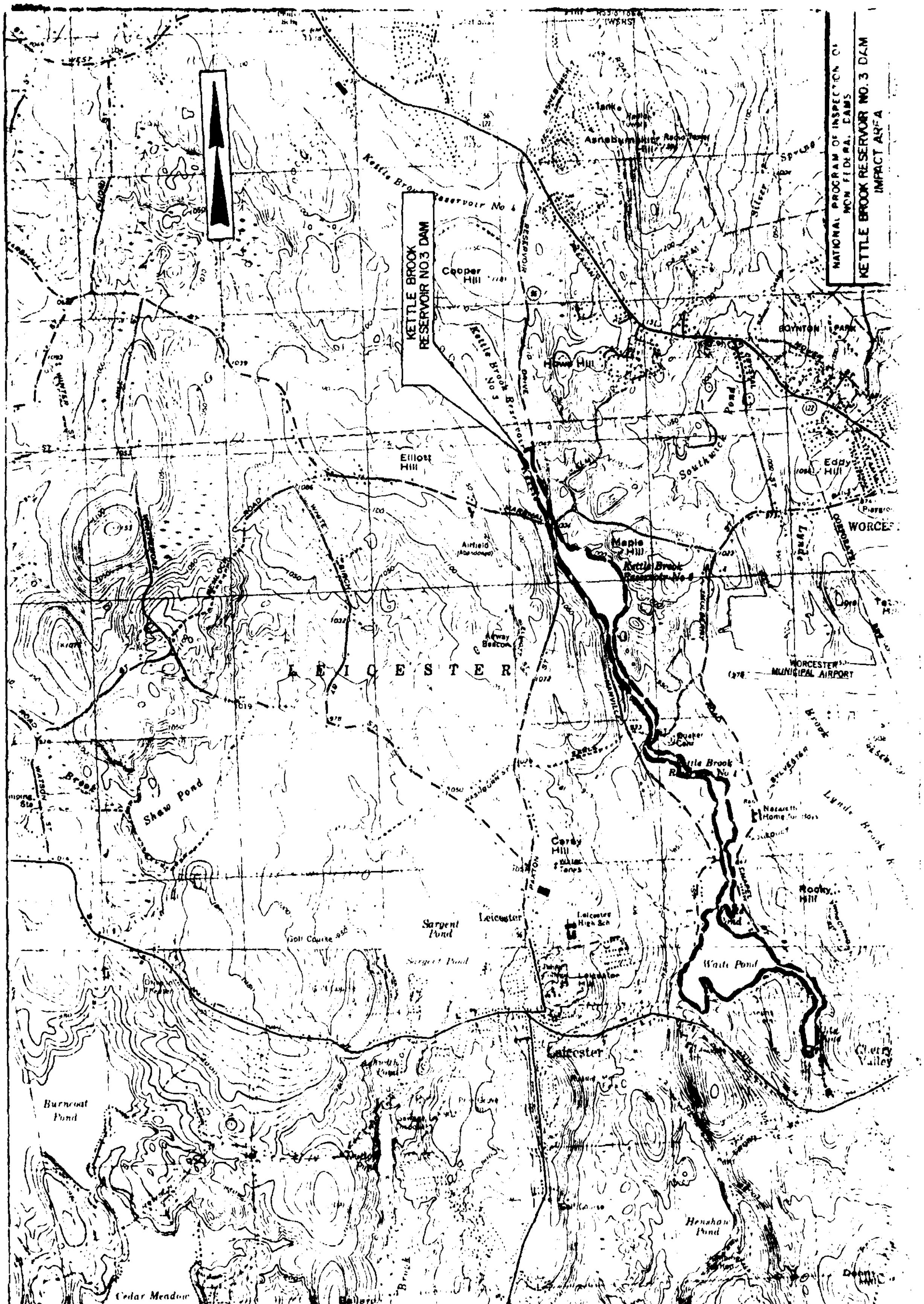
DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - SERVICE BRIDGE	Not applicable
a. Super Structure	
Bearings	
Anchor Bolts	
Bridge Seat	
Longitudinal Members	
Underside of DEck	
Secondary Bracing	
Deck	
Drainage System	
Railings	
Expansion Joints	
Paint	
b. Abutment & Piers	
General Condition of Concrete	
Alignment of Abutment	
Approach to Bridge	
Condition of Seat & Backwall	

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS


KETTLE BROOK
RESERVOIR NO 3 DAM
NATIONAL PROGRAM OF INSPECTION OF
NON FEDERAL DAMS
KETTLE BROOK RESERVOIR NO3 DAM
DRAINAGE AREA



NATIONAL PROGRAM OF INSPECTION OF
NON FEDERAL DAMS
KETTLE BROOK RESERVOIR NO.3 DAM
IMPACT AREA
KETTLE BROOK
RESERVOIR NO.3 DAM
Kettle Brook Reservoir No 4
Cooper Hill
Kettle Brook Reservoir No 3
Howe Hill
Elliott Hill
Maple Hill
Kettle Brook Reservoir No 2
Southwick Pond
Eddy Hill
BOYNTON PARK
WORCESTER MUNICIPAL AIRPORT
L E I C E S T E R
Shaw Pond
Kettle Brook Reservoir No 1
Nazareth Home for Boys
Lynde Brook
Carey Hill
Rocky Hill
Sargent Pond
Leicester
Leicester High Sch
Golf Course
Waite Pond
Cherry Valley
Burncoat Pond
Cedar Meadow Pond
Henshaw Pond
Airfield (Abandoned)

SCHOENFELD ASSOCIATES, INC.
Consulting Engineers
210 South Street
BOSTON, MASSACHUSETTS 02111
(617) 423-5541

JOB KETTLE BK. RES. NO. 3
SHEET NO. 1 OF 33
CALCULATED BY GUS S. DATE 13 MAR 81
CHECKED BY HS DATE 3-31-81
SCALE

TEST FLOOD ANALYSIS

Choose spillway design flood (SDF)

Classification - Size: Small
Hazard: High

Kettle Brook Reservoir No. 4 is located about 2500 ft. upstream of Kettle No. 3. The surface area of this upper reservoir constitutes about 8% of the total drainage area at the outlet of Kettle No. 3. Also, the outlet at Kettle No. 4 controls about 70% of this total drainage area.

Assume reservoirs 3 & 4 rise at the same rate and during the same time period. We can then consider them as one reservoir when performing surcharge storage routing.

With the above assumption in mind, compute inflow to Reservoir No. 3 as if it were combined with Reservoir No. 4...

Drainage area at No. 3 outlet $\doteq 2.55\ mi^2$

From guide curves for rolling terrain,

$$Q_{P_1} = 2050\ cfs/mi^2$$

or

$$Q_{P_1} = 2050\ (2.55\ mi^2) = 5227.5, \text{ say } 5230\ cfs$$

Total inflow to Reservoir No. 3 = 5230 cfs

SCHOENFELD ASSOCIATES, INC.
Consulting Engineers
210 South Street
BOSTON, MASSACHUSETTS 02111
(617) 423-5541

JOB KETTLE BK. RES. NO. 3
SHEET NO. 2 OF 33
CALCULATED BY G. SHARRY DATE 24APR81
CHECKED BY _____ DATE _____
SCALE _____

TEST FLOOD ANALYSIS

Surcharge Storage Routing

From previous discussion, consider Reservoir Nos. 3 & 4 as one impoundment.

$$Q_{P2} = Q_{P1} - Q_{P1}\left(\frac{\text{TOE}}{19}\right)$$

STAGE ABOVE NORMAL POOL* (FT)	SURCHARGE STORAGE° (AC-FT)	STORAGE▽ (IN.)	Q_{P2} (CFS)
1	173	1.27	4880
2	348	2.56	4525
3	533	3.92	4151
4	717	5.27	3779
5	910	6.69	3388
6	1108	8.15	2987
7	1312	9.65	2574

See surcharge storage routing curve, SH 4 / 33.

From curve intersection, PMF outflow ≐ 3000 cfs

This outflow results in overtopping of the dam embankment crest by 1.5 feet. Damage caused by erosion would be possible.

* Elevation 1040.0 @ Reservoir No. 3
° Total at Reservoir Nos. 3 & 4.
▽ Spread over entire drainage area (2.55 mi^2)

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JOB KETTLE BK DEB. NO. 3
SHEET NO. 3 OF 33
CALCULATED BY GUS S. DATE 18MAR81
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SCALE

TEST. FLOOD ANALYSIS (cont.)

Develop rating curve at dam. Assume spillway acts as a normal 34 ft.-long weir until water surface reaches 4.5 ft above spillway crest. Then assume weir flow remains constant w/ H = 4.5 feet at higher stages. This attempts to account for arch low chord that begins to interfere with flow about 2 feet above spillway crest.*

For weir flow, $Q = CLH^{3/2}$

Use "C" = 3.4 for spillway
2.7 for flow over footbridge & embankment

STAGE ABOVE SPILLWAY CREST (FT)	Q SPILLWAY (CFS)	Q EMBANK'T (CFS)	Q TOTAL (CFS)
2	327		327
3	601		601
4.5	1104		1104
5	1104	355	1459
6	1104	1872	2976
7	1104	4082	7186
8	1136	6883	8019

See rating curve, SH 4/13.

*See weir elevation, SH 6/33.

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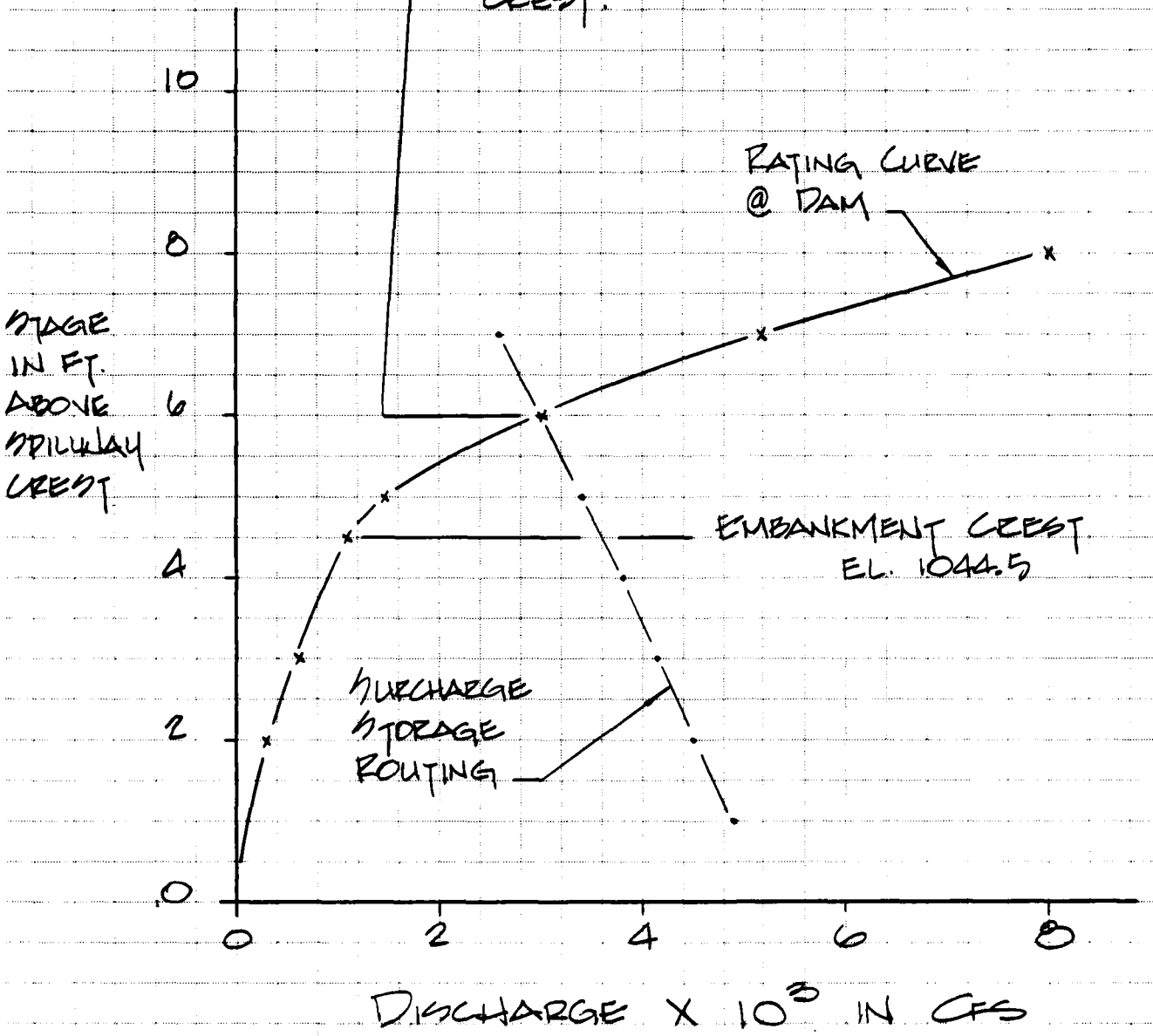
JOB KETTLE BK. RES. NO. 3
SHEET NO. 4 OF 33
CALCULATED BY G. SHARRY DATE 27 APR 81
CHECKED BY _____ DATE _____
SCALE _____

STAGE VS. DISCHARGE



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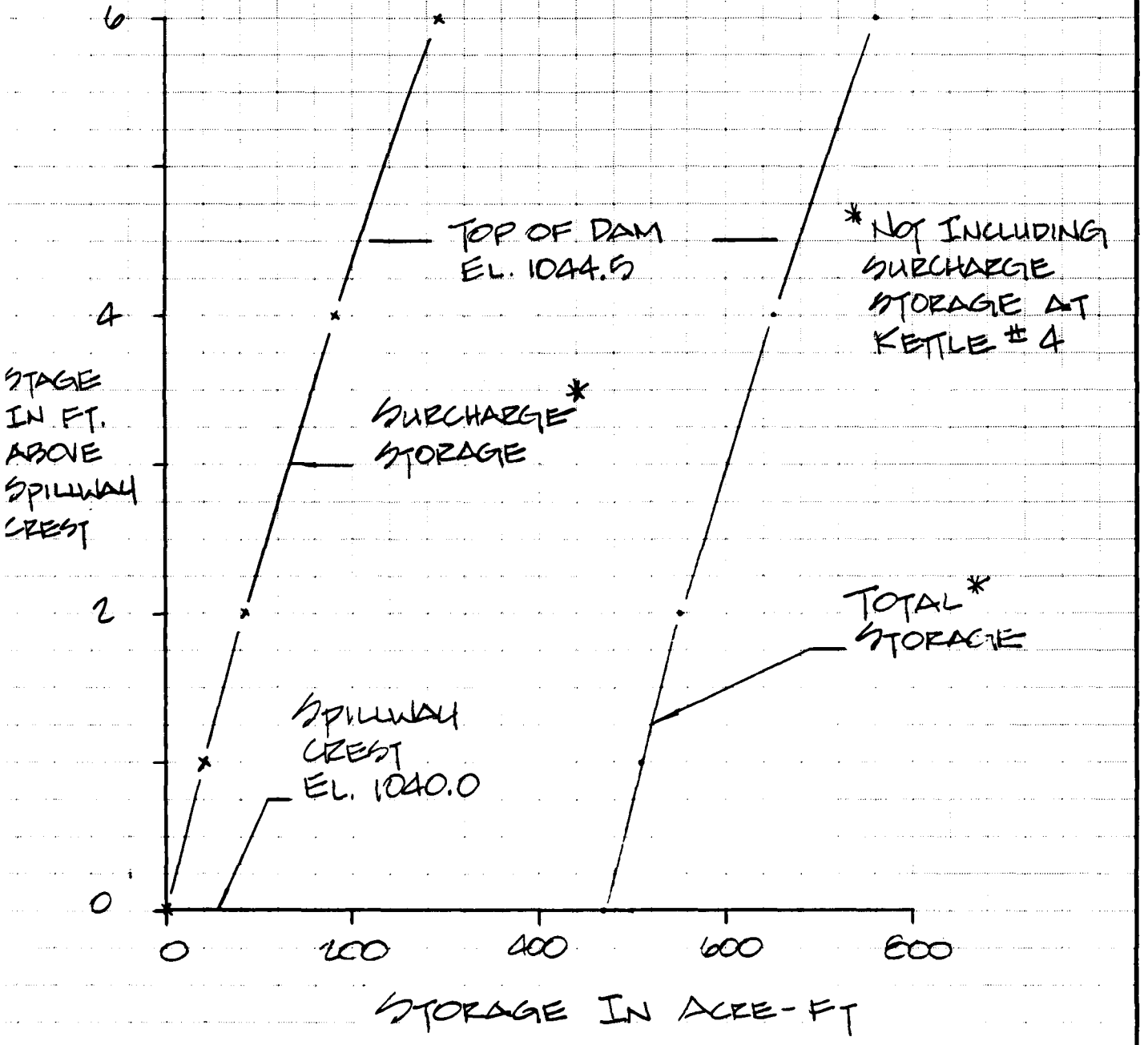
JOB KETTLE BK. RES. NO. 3
SHEET NO. 5 OF 33
CALCULATED BY GWS DATE 9 MAR 81.
CHECKED BY WS DATE 3-31-81
SCALE

KETTLE BROOK RESERVOIR NO. 3

STAGE VS. STORAGE



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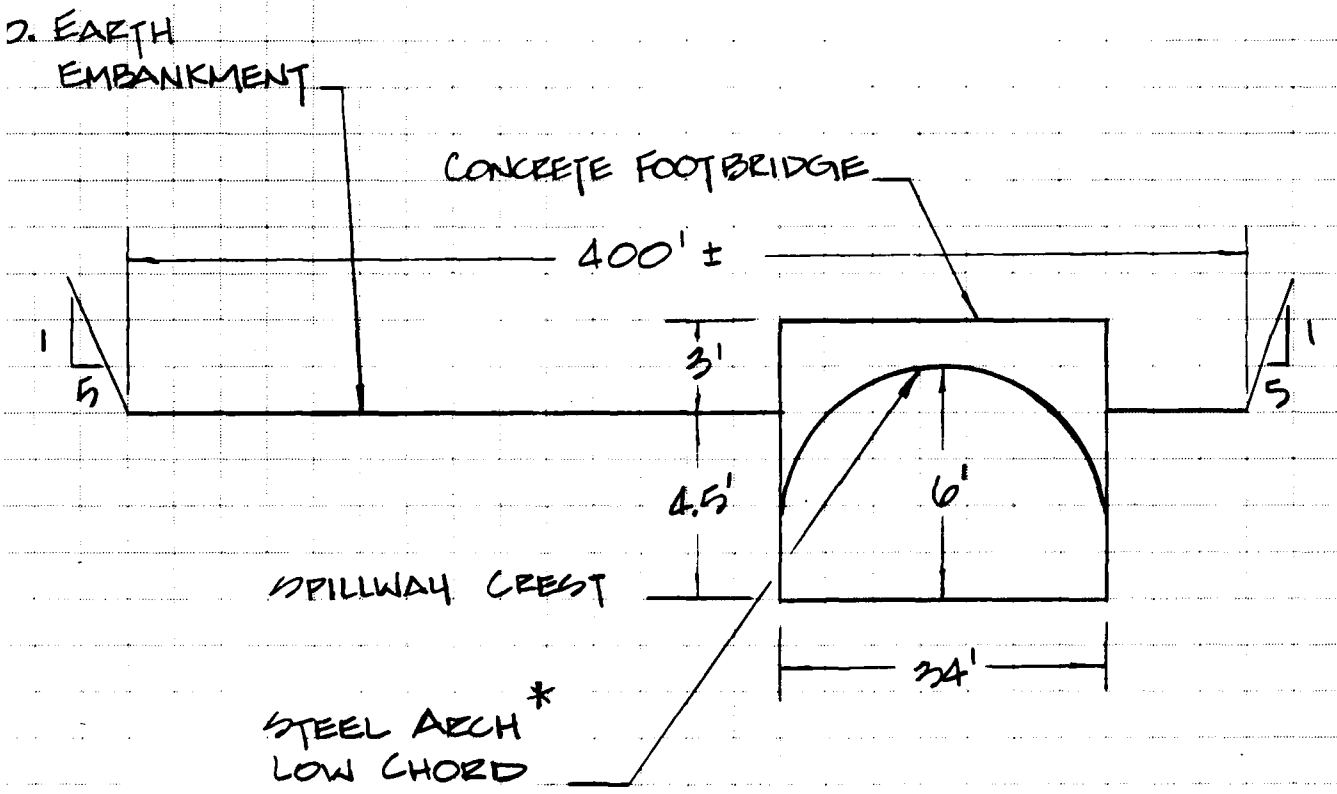
JOB KETTLE BK. RES. NO. 3
SHEET NO 6 OF 33
CALCULATED BY GWS DATE 18 MAR 81
CHECKED BY DJS DATE 3-31-81
SCALE

WEIR ELEVATION



— LOOKING UPSTREAM —

* See rating curve development, SH 3/33.

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JOB KETTLE BK. RES. NO. 3
SHEET NO. 7 OF 33
CALCULATED BY Gus S. DATE 16 MARCH 81
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SCALE

BREACH ANALYSIS

Calculate breach outflow, Q_{p_1}

$$Q_{p_1} = 8/27 \, (W_b) \sqrt{g} \, (H_o)^{3/2}$$

$W_b \equiv$ breach width @ mid-height $\doteq$ 100 ft

Use $H_o = 20$ ft

$$Q_{p_1} = 8/27 \, (100) \sqrt{32.2} \, (20)^{3/2} = 150388, \text{ say } \underline{150000} \text{ cfs}$$

Route breach flow downstream and assess potential hazards...

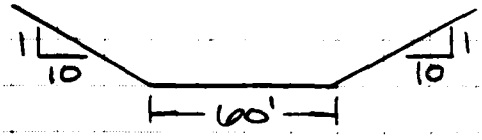
REACH 1

$L = 700$ ft. $S = 0.06$

composite "n" value = 0.06

develop rating curve for reach using Manning equation:

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



TYP. X-SECT.

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JOB KETTLE BK. RES. NO. 3
SHEET NO. 8 OF 33
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REACH ANALYSIS (cont.)

REACH 1 (cont.)

STAGE IN FT ABOVE CHANNEL BED	AREA (FT^2)	WETTED PERIMETER (FT)	Q (CFS)
2	160	100	1330
4	400	140	4890
6	720	181	11002
7	910	201	15163

See rating curve, SH 32/33.

Q_{P_1} = 15000 cfs, stage = 7.0 ft

$V_1 = \frac{700(910)}{43560} \doteq 14.6$ ac-ft $< \frac{680}{2}$ ∴ OK

$Q_{P_2(TRIAL)} = Q_{P_1}(1 - \frac{V_1}{S}) = 15000(1 - \frac{14.6}{680}) = 14678$ cfs

stage ≐ 6.9 ft $V_2 = \frac{700(890)}{43560} = 14.3$ ac-ft

V_{AVG} = 14.5 ac-ft

$Q_{P_2} = Q_{P_1}(1 - \frac{V_{AVG}}{S}) = 15000(1 - \frac{14.5}{680}) = \underline{\underline{14680}}$ cfs

stage = 6.9 ft.

No damage or loss of life would be expected along Reach 1

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SHEET NO. 9 OF 33
CALCULATED BY GUS G. DATE 16 MAR 81
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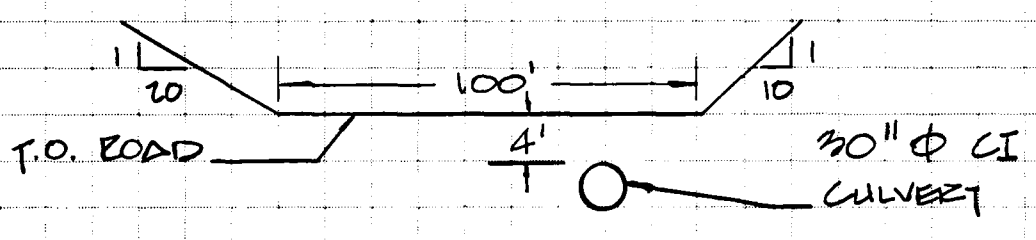
EACH ANALYSIS (cont.)

REACH 2

Downstream limit is Marshall St. culvert.

Use FHA HEC-5 charts to develop rating curve for Marshall Rd. culvert assuming inlet control; for flow over road, use $Q = CLH^{3/2}$ w/ $C = 2.7$



X-SECT LKG DOWNSTREAM

STAGE ABOVE CULVERT INV. (FT)	Q ORIFICE (CFS)	Q WEIR (CFS)	Q TOTAL (CFS)
3	28		28
6	58		58
8	70	608	678
9	75	1467	1542
10.5	81	3456	3537
12	90	6356	6446
13.5	94	10251	10345
15	100	15222	15322

See rating curve, sht 32/33.

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JOB KETTLE BK. RES. NO. 3
SHEET NO. 10 OF 33
CALCULATED BY GJS DATE 16 MAR 81
CHECKED BY HK DATE 3-31-81
SCALE

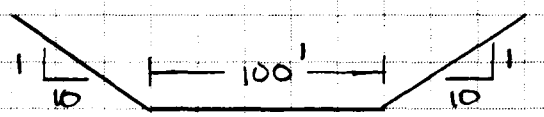
XH ANALYSIS (cont.)

REACH 2 (cont.)

Reach length = 1300 ft.

Q_{P_1} = 14680 cfs

stage = 14.8 ft.



TYP. BACKWATER STORAGE X-SECT.

$I_1 = \frac{\text{area(length)}}{43560} = \frac{3670(1300)}{43560} = 109.5$ ac-ft $< \frac{680}{2}$ ∴ OK

$Q_{P_2\,(TRIAL)} = Q_{P_1}\left(1 - \frac{V_1}{S}\right) = 14680\left(1 - \frac{109.5}{680}\right) = 12316$ cfs

stage = 14.3 ft. $V_2 = \frac{3475(1300)}{43560} = 103.7$ ac-ft

$V_{AVG} = 106.6$ ac-ft

$Q_{P_2} = Q_{P_1}\left(1 - \frac{V_{AVG}}{S}\right) = 14680\left(1 - \frac{106.6}{680}\right) = \underline{12379}$ cfs

stage = 14.3 ft.

Marshall St. would be overtopped by 7.8 feet, resulting in appreciable damage. Loss of life is possible.

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JOB KETTLE BK. RES. No. 3
SHEET NO. 11 OF 33
CALCULATED BY GUS S. DATE 16 MAR 81
CHECKED BY H. S DATE 3-31-81
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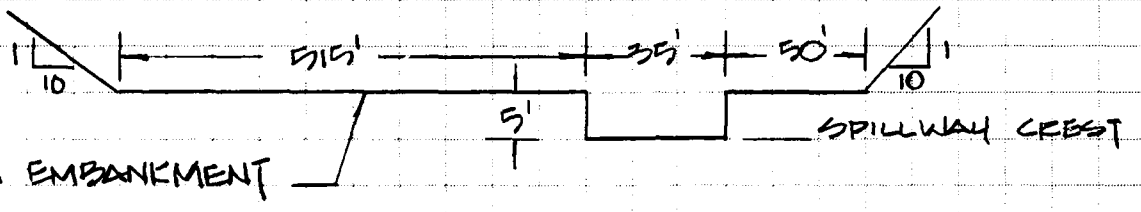
H ANALYSIS (cont.)

EACH 3

Downstream limit is dam @ Kettle Brook Reservoir No. 2.

Develop rating curve @ dam; use weir equation $Q = CLH^{3/2}$ w/ $C = 2.8$ for embankment and 3.7 for spillway; disregard low-level outlet flow.



GE ABOVE LLWAY CREST (FT)	Q SPILLWAY (CFS)	Q EMBKT (CFS)	Q TOTAL (CFS)
2	366		366
4	1036		1036
6	1903	1610	3513
8	2930	8657	11587
8.5	3209	11917	15126

e rating curve, SH 32/33.

$P_1 = 12379$ cfs, stage = 8.2 ft.

rface area of Kettle No. 2 ≐ 31 acres; an 8.2 foot se in water surface does not change the rface area of the reservoir appreciably.

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JOB KETTLE BK EES NO 3
SHEET NO. 25 OF 33
CALCULATED BY GUS S. DATE 17 MAR 81
CHECKED BY H.S. DATE 4-1-81
SCALE

+ ANALYSIS (cont.)

XCH 12 (cont.)

GE ABOVE NNEL INV (FT)	AREA (FT^2)	WETTED PERIMETER (FT)	Q (CFS)
2	150	90	838
3	248	105	1741
4	360	121	2972
6	630	151	6504

e rating curve, SH 33/33.

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JOB KETTLE BR. RES. NO. 3
SHEET NO. 24 OF 33
CALCULATED BY GUS S. DATE 17 MAR 81
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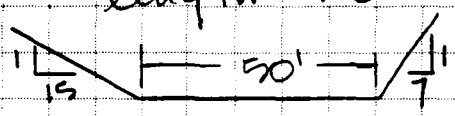
SCALE

H ANALYSIS (cont.)

XCH 11 (cont.)

= 2250 cfs

qe = 14.4 ft.



TYP. X-SECT. L'KG DOWNSTM

BACKWATER STORAGE

$\frac{\text{area (length)}}{43560} = \frac{3001(100)}{43560} = 6.9$ ac-ft $< \frac{680}{2}$ ∴ OK

$Q_{(TRIAL)} = Q_{P_1}\left(1 - \frac{V_1}{S}\right) = 2250\left(1 - \frac{6.9}{680}\right) = 2227$ cfs

qe = 14.4 ft $V_2 = 6.9$ ac-ft $V_{AVG} = 6.9$ ac-ft

$Q = Q_{P_1}\left(1 - \frac{V_{AVG}}{S}\right) = 2250\left(1 - \frac{6.9}{680}\right) = \underline{2227}$ cfs

qe = 14.4 ft.

spel St. would be overtopped by 2.4 feet
sulting in possible minor damage.

XCH 12

ength = 1000 ft. $S = 0.035$

omposite "n" value = 0.07

Develop rating curve for reach using the
lanning equation:

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

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JOB KETTLE BK. RES. NO. 3
SHEET NO. 23 OF 33
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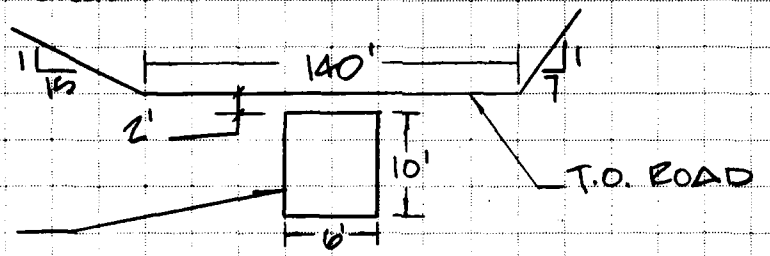
SCALE

SH ANALYSIS (cont.)

EACH 11

Downstream limit is Chapel St. culvert just downstream of Waite Pd. dam.

Develop rating curve at culvert; use FHA HEC-5 charts to rate flow through culvert assuming inlet control; use weir equation, $Q = CLH^{3/2}$ w/ C = 2.6 for flow over road.



ELEVATION LOOKING DOWNSTREAM

AGE ABOVE LVERT INV (FT)	Q ORIFICE (CFS)	Q WEIR (CFS)	Q TOTAL (CFS)
10	480		480
11	552		552
12	606		606
13	666	390	1056
14	720	1191	1911
15	780	2351	3131

ce rating curve, SH 33/33.

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JOB KETTLE BK. RES. No. 3
SHEET NO. 22 OF 33
CALCULATED BY GUS S. DATE 17 MAR 81
CHECKED BY H.S. DATE 4-1-91
SCALE

REACH ANALYSIS (cont.)

REACH 10 (cont)

STAGE ABOVE SPILLWAY CREST (FT)	Q SPILLWAY (CFS)	Q EMB'K'T (CFS)	Q TOTAL (CFS)
2	523		523
4	1480		1480
6	2719	993	3712
7	3426	2034	5460

See rating curve, SH 33/33.

$Q_{P_1} = 4147$ cfs stage = 6.3 ft.

Surface area Waite Pd. ≒ 60 ac, calculate V_1 ...

$60(6.3) = 378$ ac-ft $> \frac{680}{2}$, use $\frac{680}{2} = 340 = V_1$

$Q_{P_2\,(TRIAL)} = Q_{P_1}\left(1 - \frac{V_1}{S}\right) = 4147\left(1 - \frac{340}{680}\right) = 2074$ cfs

stage = 4.7 ft. $V_2 = 60(4.7) = 282$ ac-ft.

$V_{AVG} = 311.0$ ac-ft.

$Q_{P_2} = Q_{P_1}\left(1 - \frac{V_{AVG}}{S}\right) = 4147\left(1 - \frac{311.0}{680}\right) = \underline{2250}$ cfs

stage = 4.8 ft.

The dam at Waite Pd would be overtopped by 0.8 feet. Some damage to the dam structure could occur.

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JOB KETTLE BK RES. NO. 3
SHEET NO. 21 OF 33
CALCULATED BY GUS S. DATE 17 MAR 81
CHECKED BY H.S. DATE 4-1-81
SCALE

EACH ANALYSIS (cont.)

REACH 9 (cont.)

$Q_{P_1} = 4225$ cfs stage = 6.1 ft.

$V_1 = \frac{\text{area (length)}}{43560} = \frac{924(600)}{43560} = 12.7$ ac-ft $< \frac{680}{2}$ ∴ OK

$Q_{P_2(TRIAL)} = Q_{P_1}\left(1 - \frac{V_1}{S}\right) = 4225\left(1 - \frac{12.7}{680}\right) = 4146$ cfs

stage = 6.0 ft. $V_2 = \frac{900(600)}{43560} = 12.4$ ac-ft.

$V_{AVG} = 12.6$ ac-ft

$Q_{P_2} = Q_{P_1}\left(1 - \frac{V_{AVG}}{S}\right) = 4225\left(1 - \frac{12.6}{680}\right) = 4147$ cfs

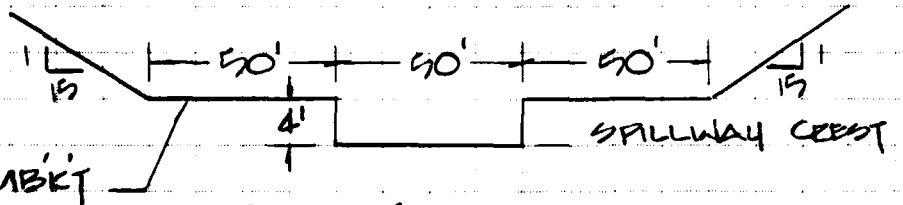
stage = 6.0 ft.

Two inhabited structures located along Reach 9 would experience some minor flooding (< 2 ft.)

REACH 10

Downstream limit is dam on Waite Pond.

Develop rating curve at dam using weir equation, $Q = CLH^{3/2}$; use $C = 3.7$ for spillway, $C = 2.7$ for embankment.



DAM ELEVATION

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JOB KETTLE BK. RES. NO. 3
SHEET NO. 20 OF 33
CALCULATED BY GUS S. DATE 17 MAR 81
CHECKED BY H.S. DATE 4-1-81
SCALE

REACH ANALYSIS (cont.)

REACH 8 (cont.)

Mulberry Road would be inundated by about 2.8 feet of water, possibly resulting in damage to the roadway and stone headwall.

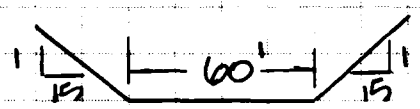
REACH 9

Length = 600 ft $S = 0.008$

Composite "n" value = 0.07

Develop rating curve for reach using the Manning equation,

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



TYP. X-SECT.

STAGE ABOVE CHANNEL INV (FT)	AREA (FT^2)	WETTED PERIMETER (FT)	Q (CFS)
2	180	120	449
4	480	180	1755
6	900	240	4131
7	1155	271	5787

See rating curve, SH 33/33.

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JOB KETTLE BR. RES. NO. 3
SHEET NO. 19 OF 33
CALCULATED BY GLS S. DATE 17 MAR 81
CHECKED BY H.S. DATE 4-1-81
SCALE

BREACH ANALYSIS (cont.)

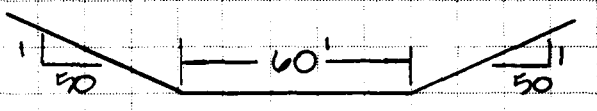
REACH B (cont.)

STAGE ABOVE CHANNEL INV (FT)	Q ORIFICE (CFS)	Q WEIR (CFS)	Q TOTAL (CFS)
6	592		592
9	960		960
12	1216		1216
15	1456	3242	4698
16	1488	5376	6864

See rating curve, SH 32/33.

$Q_{P_1} = 5477$ cfs

stage = 155.5 ft.



TYP. X-SECTION
BACKWATER STORAGE

$V_1 = \frac{\text{area(length)}}{43560} = \frac{12943(550)}{43560} = 163.4$ ac-ft $< \frac{680}{2}$ ∴ OK

$Q_{P_2\,(TRIAL)} = Q_{P_1}\left(1 - \frac{V_1}{5}\right) = 5477\left(1 - \frac{163.4}{680}\right) = 4161$ cfs

stage = 14.7 ft $\quad V_2 = \frac{11687(550)}{43560} = 147.6$ ac-ft

$V_{AVG.} = 155.5$ ac-ft

$Q_{P_2} = Q_{P_1}\left(1 - \frac{V_{AVG}}{5}\right) = 5477\left(1 - \frac{155.5}{680}\right) = \underline{\underline{4225}}$ cfs

stage = 14.8 ft

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JOB KETTLE BK. RES. NO. 3
SHEET NO. 18 OF 33
CALCULATED BY GUS S. DATE 17 MAR 81
CHECKED BY H.S. DATE 4-1-81
SCALE

BREACH ANALYSIS (cont.)

REACH 7 (cont.)

$Q_{P_2\,(TRIAL)} = 6383\left(1 - \frac{98.6}{680}\right) = 5457$ cfs

stage = 6.5 ft $\quad V_2 = 12\left(\frac{6.5}{2}\right) + 17\left(\frac{6.5}{2}\right) = 94.3$ ac-ft

$V_{AVG} = 96.5$ ac-ft

$Q_{P_2} = 6383\left(1 - \frac{96.5}{680}\right) = \underline{\underline{5477}}$ cfs

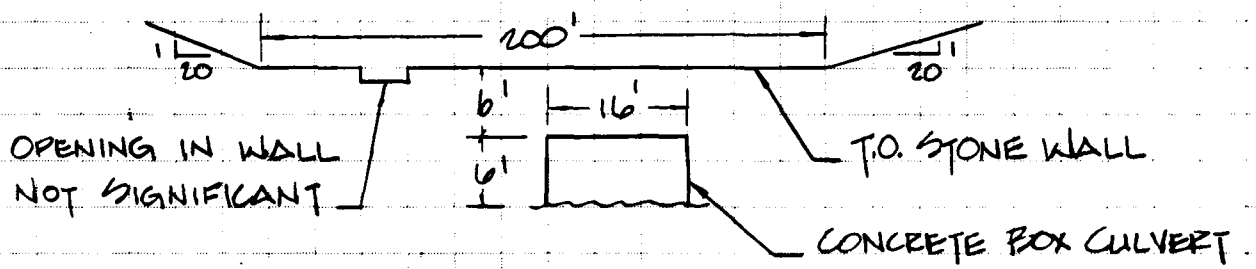
stage = 6.5 ft.

The dam embankment would be overtopped by about 2.0 feet. This could result in damage to the earth embankment.

REACH 8

Downstream limit is Mulberry Road bridge culvert.

Develop rating curve at Mulberry Rd. Use FHA HEC-5 charts to rate culvert flow; use weir equation, $Q = CLH^{3/2}$ w/ $C = 2.4$ for flow over road, assume inlet controlled orifice flow.



ELEVATION LOOKING DOWNSTREAM

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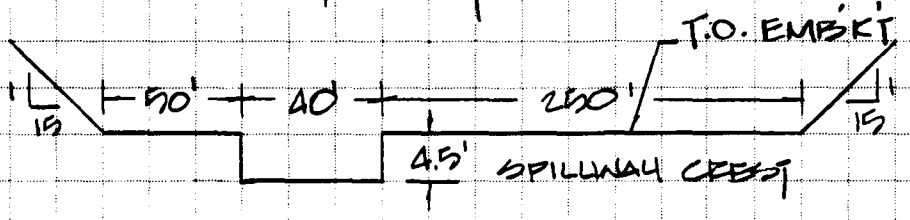
JOB KETTLE BK RES. NO. 3
SHEET NO. 17 OF 33
CALCULATED BY Gus S. DATE 17 MAR 81
CHECKED BY H. S. DATE 4-1-81
SCALE

BREACH ANALYSIS (cont.)

REACH 7

Downstream limit is dam at Kettle Brook Reservoir No. 1.

Develop rating curve at dam using weir equation, $Q = CLH^{3/2}$, $C = 2.8$ over embankment, $C = 3.7$ over spillway



DAM ELEVATION L'K'G UPSTREAM

STAGE ABOVE SPILLWAY CREST (FT)	Q SPILLWAY (CFS)	Q EMBANK'T (CFS)	Q TOTAL (CFS)
2	419		419
4	1184		1184
5	1655	304	1959
6	2175	1659	3834
7	2741	4483	7224

See rating curve, SH 32/33.

$Q_{P_1} = 6383$ cfs, stage = 6.8 ft.

Surface area of Kettle No. 1 ≈ 12 ac. @ el. 845.0
17 ac. @ el. 851.8 $\Delta = 6.8'$

$V_1 = 12\left(\frac{6.8}{2}\right) + 17\left(\frac{6.8}{2}\right) = 98.6$ ac-ft $< \frac{680}{2}$ ∴ OK

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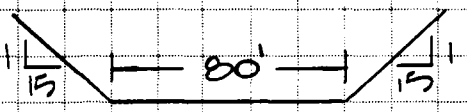
JOB KETTLE BK. RES. NO. 3
SHEET NO. 16 OF 33
CALCULATED BY GHS DATE 17 MAR 81
CHECKED BY H.S. DATE 4-1-81
SCALE

BREACH ANALYSIS (cont.)

REACH 6 (cont.)



TYP. X-SECTION

STAGE ABOVE CHANNEL INV (FT)	AREA (FT^2)	WETTED PERIMETER (FT)	Q (CFS)
2	220	140	959
4	560	200	3587
6	1020	260	8181

see rating curve, SH 32/33.

$Q_{P_1} = 6910$ cfs, stage = 5.5 ft

$V_1 = \frac{\text{area(length)}}{43560} = \frac{894(2600)}{43560} = 53.4$ ac-ft $< \frac{680}{2}$ ∴ OK

$Q_{P_2(TRIAL)} = Q_{P_1}(1 - \frac{V_1}{5}) = 6910(1 - \frac{53.4}{680}) = 6367$ cfs

stage = 5.3 ft. $V_2 = \frac{845(2600)}{43560} = 50.4$ ac-ft.

$V_{AVG} = 51.9$ ac-ft

$Q_{P_2} = Q_{P_1}(1 - \frac{V_{AVG}}{5}) = 6910(1 - \frac{51.9}{680}) = \underline{\underline{6383}}$ cfs

stage = 5.3 ft.

No damage would be expected along reach 6.

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JOB KETTLE BK RES. No. 3
SHEET NO. 15 OF 33
CALCULATED BY GUS S. DATE 17 MAR 81
CHECKED BY H.S. DATE 4-1-81
SCALE

BREACH ANALYSIS (cont.)

REACH 5 (cont.)

$Q_{P_1} = 7399$ cfs , stage = 11.5 ft

$V_1 = \frac{\text{area (length)}}{43560} = \frac{3048(650)}{43560} = 45.5$ ac-ft $< \frac{680}{2}$ ∴ OK

$Q_{P_2(TRIAL)} = Q_{P_1}\left(1 - \frac{V_1}{5}\right) = 7399\left(1 - \frac{45.5}{680}\right) = 6904$ cfs

stage = 11.3 ft $V_2 = \frac{2972(650)}{43560} = 44.3$ ac-ft

$V_{AVG} = 44.9$ ac-ft

$Q_{P_2} = Q_{P_1}\left(1 - \frac{V_{AVG}}{5}\right) = 7399\left(1 - \frac{44.9}{680}\right) = \underline{\underline{6910}}$ cfs

stage = 11.3 ft.

Earle St. would be overtopped by 4.3 feet causing appreciable damage to its sand and gravel surface.

REACH 6

Length = 2600 ft $S = 0.023$

Composite "n" value = 0.07

Develop rating curve for reach using the Manning equation:

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

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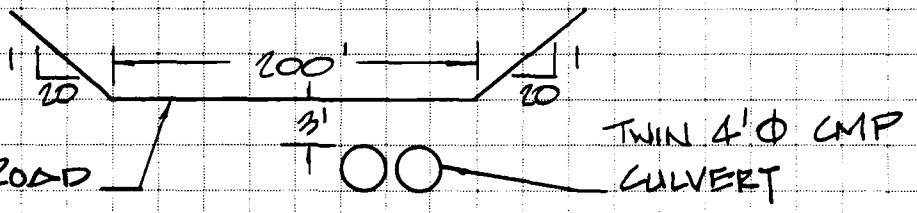
JOB KETTLE BK. RES. NO. 3
SHEET NO. 14 OF 33
CALCULATED BY GUS S. DATE 17 MAR 81
CHECKED BY H S. DATE 4-1-81
SCALE

BREACH ANALYSIS (cont.)

REACH 5

Downstream limit is Earle St. culvert

Develop rating curve at culvert. Use FHA HEC-5 charts to compute orifice flow assuming inlet control; for flow over road, $Q = CLH^{3/2}$ w/ $C = 2.7$.

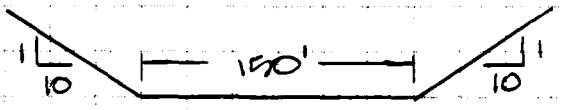


X-SECT. L'KG UPSTREAM

STAGE ABOVE CHANNEL INV (FT)	Q ORIFICE (CFS)	Q WEIR (CFS)	Q TOTAL (CFS)
4	144		144
6	230		230
8	290	594	884
10	340	3648	3988
12	390	9056	9446

See rating curve, SH 32/33.

Reach length = 650 ft.



TYP. X-SECTION
BACKWATER STORAGE

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JOB KETTLE BE. RES. NO. 3
SHEET NO. 13 OF 33
CALCULATED BY GUS S. DATE 17 MAR 81
CHECKED BY H.S. DATE 4-1-81
SCALE

BREACH ANALYSIS (cont.)

REACH 4 (cont.)

STAGE ABOVE CHANNEL INV. (FT)	AREA (FT^2)	WETTED PERIMETER (FT)	Q (CFS)
1	87	94	337
3	303	122	2263
5	575	151	5729
7	903	179	10828

See rating curve, SH 32/33.

Q_{P_1} = 7977 cfs, stage = 6.0 ft.

$V_1 = \frac{732(3000)}{43560} = 50.4$ ac ft $< \frac{680}{2}$ ∴ OK

$Q_{P_2(TRIAL)} = Q_{P_1}(1 - \frac{V_1}{5}) = 7977(1 - \frac{50.4}{680}) = 7386$ cfs

stage = 5.8 ft, $V_2 = \frac{699(3000)}{43560} = 48.1$ ac-ft

V_{AVG} = 49.3 ac-ft

$Q_{P_2} = Q_{P_1}(1 - \frac{V_{AVG}}{5}) = 7977(1 - \frac{49.3}{680}) =$ <u>7399</u> cfs

stage = 5.8 ft.

No structural damage would occur along this reach.

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JOB KETTLE BE RES. NO. 3
SHEET NO. 12 OF 33
CALCULATED BY GUS S. DATE 16MAR81
CHECKED BY HS DATE 4-1-81
SCALE

BREACH ANALYSIS (cont.)

REACH 3 (cont.)

$V_1 = 8.2(31) = 254.2$ ac-ft $< \frac{680}{2}$ ∴ OK

$Q_{P2\,(TRIAL)} = Q_{P1}\left(1 - \frac{V_1}{S}\right) = 12379\left(1 - \frac{254.2}{680}\right) = 7751$ cfs

stage = 7.4 ft $\qquad V_2 = 7.4(31) = 229.4$ ac-ft

$V_{AVG} = 241.8$ ac-ft

$Q_{P2} = Q_{P1}\left(1 - \frac{V_{AVG}}{S}\right) = 12379\left(1 - \frac{241.8}{680}\right) = \underline{\underline{7977}}$ cfs

stage = 7.4 ft.

The dam embankment at Kettle No. 2 would be overtopped by 2.4 ft. Appreciable damage to the embankment could occur.

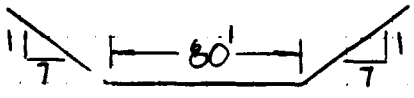
REACH 4

L = 3000 ft. $\qquad S = 0.027$

composite "n" value ≐ 0.06

develop rating curve for reach using Manning equation:

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



TYP. X-SECT.

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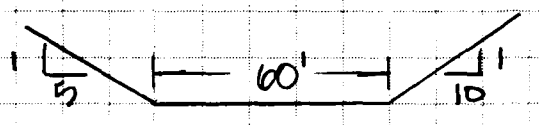
JOB KETTLE BK. RES. NO. 5
SHEET NO. 26 OF 33
CALCULATED BY GUS S. DATE 17 MAR 81
CHECKED BY H. S. DATE 4-1-81
SCALE

BREACH ANALYSIS (cont.)

REACH 12 (cont.)

$Q_{p_1} = 2227$ cfs



stage = 3.5 ft. THP. X-SECT. U/S DWSTM

$V_1 = \frac{\text{area (length)}}{43560} = \frac{304\,(1000)}{43560} = 7.0$ ac-ft $< \frac{680}{2}$ ∴ OK

$Q_{p_2\,(TRIAL)} = Q_{p_1}\left(1 - \frac{V_1}{5}\right) = 2227\left(1 - \frac{7.0}{680}\right) = 2204$ cfs

stage = 3.4 ft. $V_2 = \frac{290(1000)}{43560} = 6.6$ ac-ft.

$V_{AVG} = 6.8$ ac-ft.

$Q_{p_2} = Q_{p_1}\left(1 - \frac{V_{AVG}}{5}\right) = 2227\left(1 - \frac{6.8}{680}\right) = \underline{2205}$ cfs

stage = 3.4 ft.

No damage would be expected along Reach 12.

REACH 13

Downstream limit is lower Chapel St. culvert.

Develop rating curve at culvert. Use FHA HEC-5 charts to rate orifice flow assuming inlet control; Use weir equation, $Q = CLH^{3/2}$, w/ $C = 2.6$ for flow over road.

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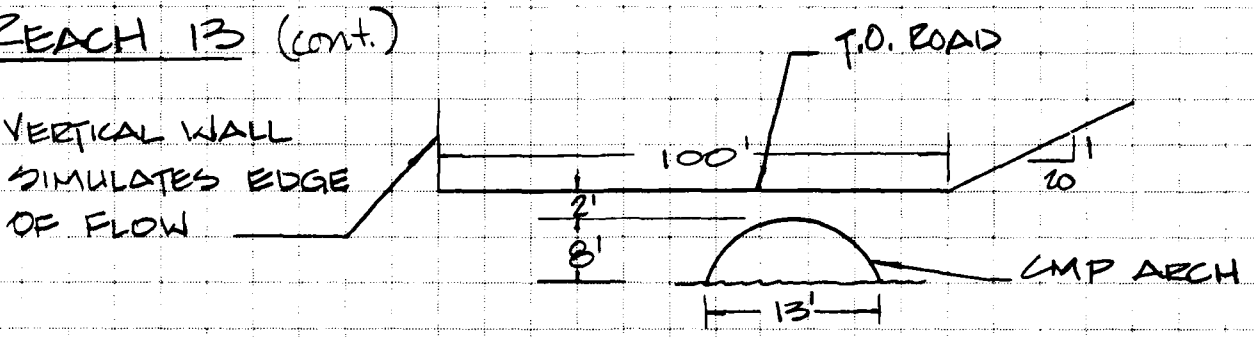
SHEET NO. 27 OF 33
CALCULATED BY GUS S. DATE 17 MAR 81
CHECKED BY H.S. DATE 4-1-81
SCALE

BREACH ANALYSIS (cont.)

REACH 13 (cont.)



ELEVATION LOOKING DOWNSTREAM

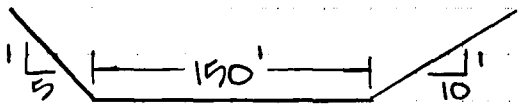
STAGE ABOVE CULVERT INV (FT)	Q ORIFICE (CFS)	Q WEIR (CFS)	Q TOTAL (CFS)
8	710		710
9	800		800
10	900		900
11	960	546	1506
12	1050	1618	2668

see rating curve, SH 33/33.

$Q_{P_1} = 2205$ c/s

stage = 11.7 ft

length = 350 ft.



TYP. X-SECT. L'K'G DOWNST'M BACKWATER STORAGE

$V_1 = \frac{\text{area}(\text{length})}{43560} = \frac{2782(350)}{43560} = 22.4$ ac-ft $< \frac{680}{2}$ ∴ OK

$Q_{P_2(\text{TRIAL})} = Q_{P_1}\left(1 - \frac{V_1}{5}\right) = 2205\left(1 - \frac{22.4}{680}\right) = 2132$ c/s

stage = 11.7 ft. $V_2 = V_1 = 22.4$ ac-ft

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JOB KETTLE BK RES. NO. 3
SHEET NO. 28 OF 33
CALCULATED BY GUS S. DATE 17 MAR 81
CHECKED BY HJ DATE 4-1-81
SCALE

BREACH ANALYSIS (cont.)

REACH 13 (cont)

$$Q_{P2} = Q_{P1}\left(1 - \frac{V_{AVG}}{5}\right) = 2205\left(1 - \frac{22.4}{680}\right) = \underline{\underline{2132}} \text{ cfs}$$

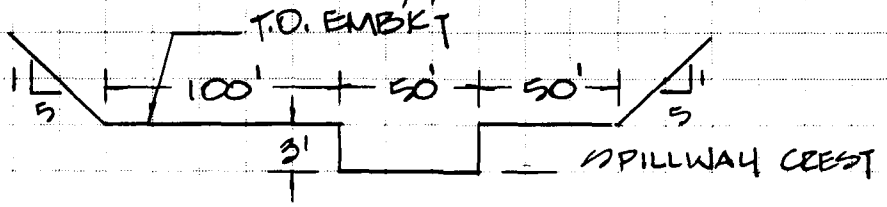
Stage = 11.7 ft.

Chapel St. would be overtopped by 1.7 feet, resulting in minor damage.

REACH 14

Downstream limit is dam located about 850 feet downstream of Reach 13 termination.

Develop rating curve at dam using weir equation, $Q = CLH^{3/2}$, w/ C = 3.7 for spillway and 2.8 for embankment.



ELEVATION LOOKING DOWNSTREAM

STAGE ABOVE SPILLWAY CREST (FT)	Q SPILLWAY (CFS)	Q EMB'K'T (CFS)	Q TOTAL (CFS)
2	523		523
3	961		961
4	1480	434	1914
5	2068	1267	3335

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SHEET NO. 29 OF 33
CALCULATED BY Gus S. DATE 17 MAR 81
CHECKED BY H.S. DATE 4-1-81
SCALE

BREACH ANALYSIS (cont.)

REACH 14 (cont.)

See rating curve, WH 33/33.

$Q_{P_1} = 2132$ cfs stage = 4.2 ft.

surface area of pond ≐ 3.7 ac.

$V_1 = 3.7(4.2) = 15.5$ ac-ft $< \frac{680}{2}$ ∴ OK

$Q_{P_2(TRIAL)} = Q_{P_1}\left(1 - \frac{V_1}{S}\right) = 2132\left(1 - \frac{15.5}{680}\right) = 2083$ cfs

stage = 4.2 ft. $V_2 = V_1 = 15.5$ ac-ft $= V_{AVG}$

$Q_{P_2} = Q_{P_2(TRIAL)} = \underline{\underline{2083}}$ cfs

stage = 4.2 ft.

The dam would be overtopped by 1.2 feet. As this dam is in poor condition, appreciable damage could result from overtopping.

REACH 15

Downstream limit is factory located below dam at termination of Reach 14.

Develop rating curve at factory. Use FHA HEC-5 charts to rate flow through culvert below factory; use weir equation, $Q = CLH^{3/2}$ to rate flow around sides of factory, $C = 2.5$

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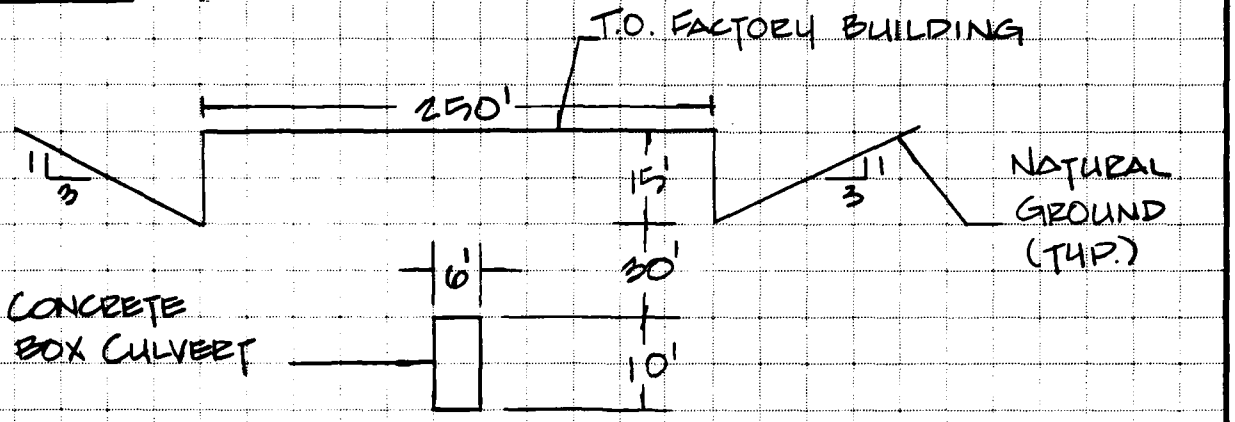
JOB KETTLE BK. LEVS. NO. 3
SHEET NO. 30 OF 33
CALCULATED BY GUS S. DATE 17 MAR 81
CHECKED BY HS DATE 4-1-81
SCALE

BREACH ANALYSIS (cont.)

REACH 15 (cont.)

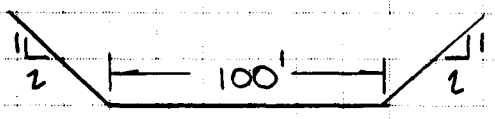


ELEVATION LOOKING DOWNSTREAM

STAGE ABOVE CULVERT INV (FT)	Q ORIFICE (CFS)	Q WEIR (CFS)	Q TOTAL (CFS)
10	540		540
15	870		870
20	1116		1116
30	1500		1500
40	1800		1800
42	1800	42	1902
44	1920	240	2160

See rating curve, SH 33/33.

Q_{P_1} = 2083 cfs stage = 43.5 ft



length = 50 ft

TYP. X-SECT.
BACKWATER STORAGE

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JOB KETTLE BK. RES. NO. 3
SHEET NO. 31 OF 33
CALCULATED BY GUS S. DATE 17 MAR 81
CHECKED BY H.S. DATE 4-1-81
SCALE

BREACH ANALYSIS (cont.)

REACH 15 (cont)

$V_1 = \underset{43560}{\text{area (length)}} = \underset{43560}{8135(50)} = 9.3 \text{ ac-ft} < \frac{680}{2}$ ∴ OK

$Q_{P_2(TRIAL)} = Q_{P_1}\left(1 - \frac{V_1}{S}\right) = 2083\left(1 - \frac{9.3}{680}\right) = 2055$ cfs

stage = 43.5 ft. $V_2 = V_1 = 9.3$ ac-ft $= V_{AVG}$

$Q_{P_2} = Q_{P_1}\left(1 - \frac{V_{AVG}}{S}\right) = 2083\left(1 - \frac{9.3}{680}\right) = \underline{2055}$ cfs

stage = 43.5 ft.

The factory would be inundated* with only the top ten feet of the building escaping flooding. This building is in use and, therefore, the potential exists for excessive damage and loss of life.

Accordingly, Kettle Brook Reservoir No. 3 is classified as <u>High</u> Hazard.

*Since the factory is located immediately downstream of a dam in a narrow valley, an increase in depth of water of 20 feet due to breach flow would not be out of the ordinary.

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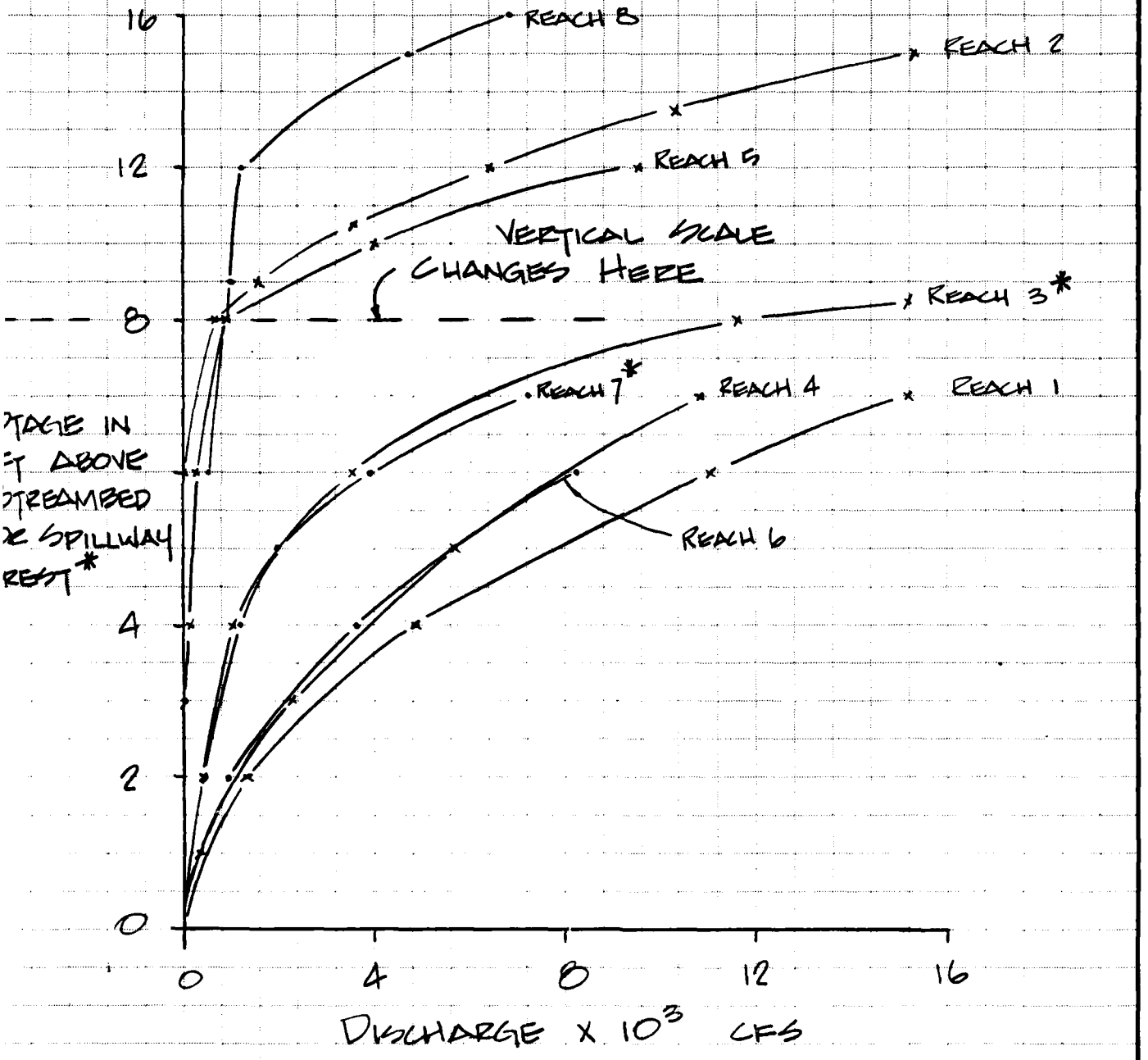
JOB KETTLE BK. DES NO. 5
SHEET NO. 32 OF 33
CALCULATED BY GLS DATE 11 MAR 81
CHECKED BY HJS DATE 4-1-81
SCALE

BREACH ANALYSIS
REACH RATING CURVES



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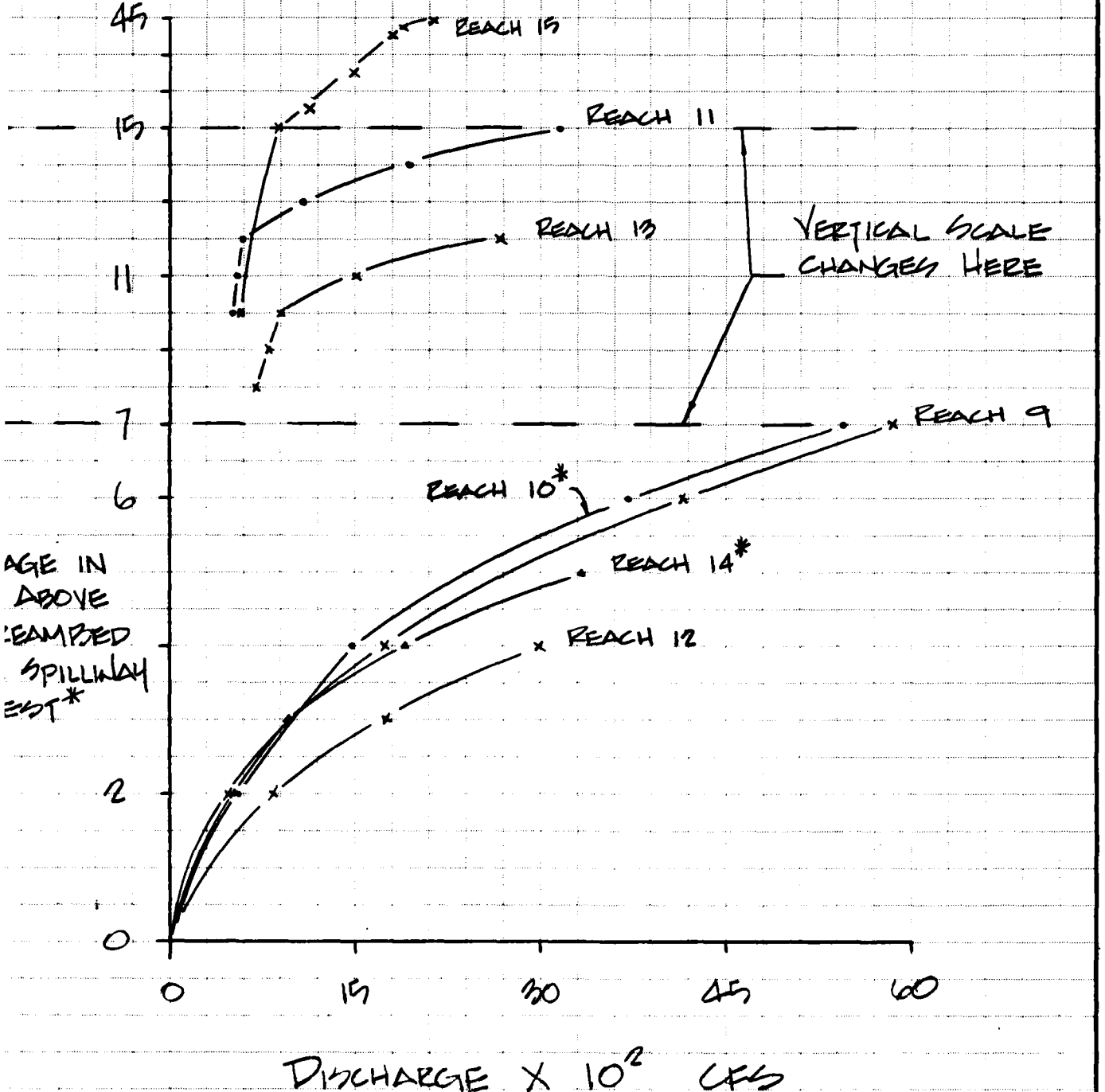
JOB KETTLE BK. RES. NO. 5
SHEET NO. 33 OF 33
CALCULATED BY GUS S. DATE 16 MAR 81
CHECKED BY H.S. DATE 4-1-81
SCALE

BREACH ANALYSIS

REACH RATING CURVES



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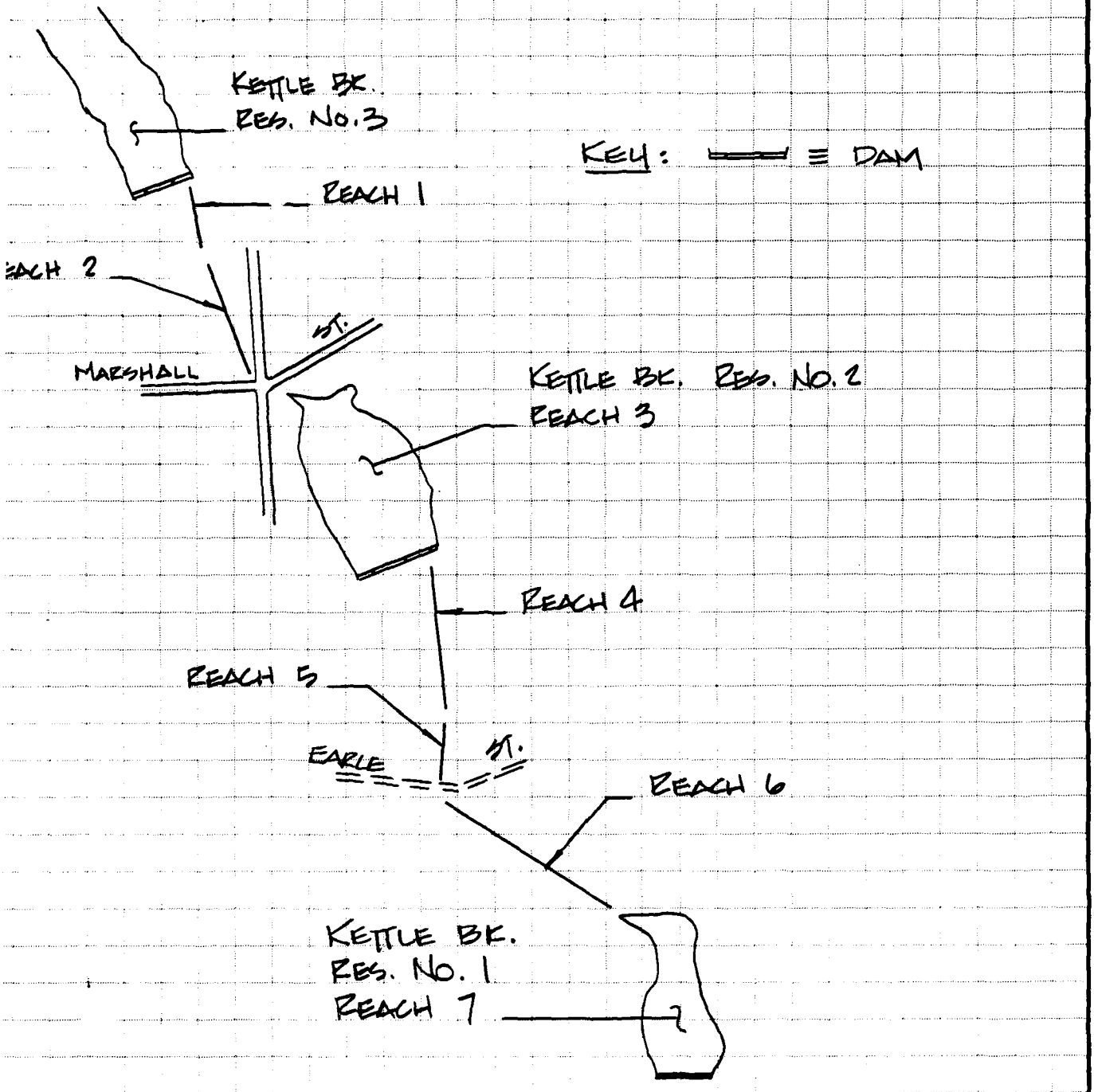
JOB KETTLE BK. RES. NO. 3
SHEET NO. ATTACH. A 1 OF 2
CALCULATED BY GUS S. DATE 19 MAR 81
CHECKED BY _____ DATE _____
SCALE _____

BREACH SCHEMATIC



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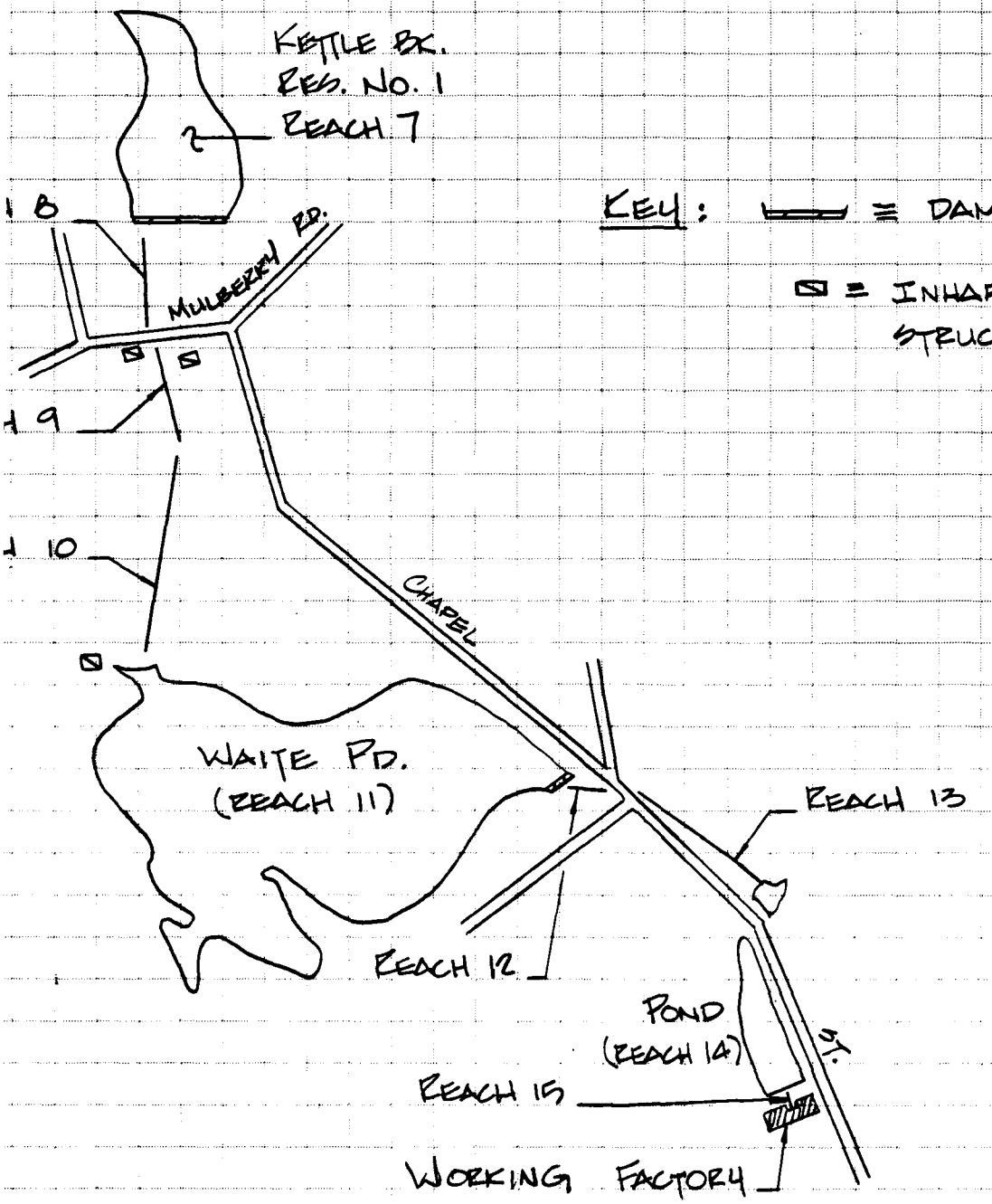
JOB KETTLE BR. RES. NO. 2
SHEET NO. ATTACH. A 1 OF 2
CALCULATED BY GWS S. DATE 19 MAR 81
CHECKED BY _____ DATE _____
SCALE _____

BREACH SCHEMATIC (cont.)



KEY: ▭ = DAM

▭ = INHABITED STRUCTURE

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

END

FILMED

8-85

DTIC