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NATIONAL DAM SAFETY PROGRAM, ALFRED B. BUHL, JR. LAKE DAM (MO 3--ETC(U)
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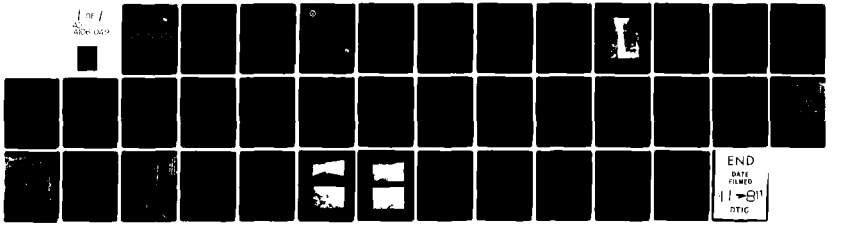

LEVEL II

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MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

AD A106049

ALFRED B. BUHL, JR. LAKE DAM
JEFFERSON COUNTY, MISSOURI
MO 30464

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY: U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

SEPTEMBER 1978

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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18. SUPPLEMENTARY NOTES	
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams	
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.	

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Alfred B. Buhl, Jr. Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Alfred B. Buhl, Jr. Lake Dam.

It was prepared under the National Program of Inspection of Non-Federal Dams.

The St. Louis District has classified this dam as unsafe, non-emergency because the spillway will not pass 50 percent of the Probable Maximum Flood.

SUBMITTED BY: SIGNED
Chief, Engineering Division

19 SEP 1978
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer

19 SEP 1978
Date

ALFRED B. BUHL, JR. LAKE DAM
ST. LOUIS COUNTY, MISSOURI

MISSOURI INVENTORY NO. 30464

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

HORNER & SHIFRIN, INC.
5200 OAKLAND AVENUE
ST. LOUIS, MISSOURI 63110

FOR:

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS

SEPTEMBER 1978

HS-7848

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam: Alfred B. Buhl, Jr.
State Located: Missouri
County Located: Jefferson
Stream: Tributary La Barque Creek
Date of Inspection: 28 June 1978

The Buhl Lake Dam was visually inspected by engineering personnel of the office of Horner & Shifrin, Inc., Consulting Engineers, St. Louis, Missouri. The purpose of the inspection was to assess the general condition of the dam with respect to safety and, based upon this inspection and available data, determine if the dam poses a hazard to human life or property.

Based on a visual inspection, the present general condition of the dam is considered to be substandard. The following deficiencies were noticed during the inspection and are considered to have an adverse effect on the overall safety and future operation of the dam:

1. Several holes that appear to be animal burrows were observed in the crest of the dam. These burrows create voids through which seepage of water through the dam may occur and if left unattended can develop into a piping condition.

2. A heavy cover of small- and medium-sized trees and brush exist on the downstream slope of the dam. The tree roots in time may provide a pathway for lake seepage. Some seepage was noticed at the toe of the downstream slope at a point near the center of the dam. Some minor surface erosion of the slope at this location was also noticed. At the time of the inspection, the cause of this erosion could not

be determined. The downstream slope of the dam should be more thoroughly examined when the brush and tree growth are removed.

3. The outlet channel beginning at a point approximately 70 feet downstream from the control point of the excavated earth spillway was noticeably eroded. This condition is not believed to be serious at this time, although the possibility exists that continued erosion may back-cut the spillway top and lower the crest elevation, thus affecting the operation of the lake.

4. The upstream slope has a grass cover to protect it from erosion by wave action. A grass covered slope is not considered adequate to protect the slope against erosion by wave action. Erosion of the bank will reduce the cross section of the dam and could result in instability and/or overtopping.

The crest of the dam was found to be approximately 1.4 feet lower at a location near the center of the dam than the crest of the dam in the area adjacent to the spillway. As a result of this low top of dam section, the capacity of the spillway to discharge lake outflow is reduced considerably. The depth of lake outflow at the spillway is limited to about 0.5 foot before lake surcharge will overflow the center of the dam. According to the criteria set forth in the recommended guidelines (see text) the minimum spillway design flood for this dam, which is classified as small in size and of high hazard potential, is specified to be one-half Probable Maximum Flood (1/2 PMF). PMF is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. Results of a hydrologic/hydraulic analysis indicated the existing spillway to be inadequate to pass lake outflow resulting from a storm of 1/2 PMF magnitude or the lake outflow resulting from the 1 percent chance (100-year frequency) flood. The length of the downstream damage zone, should failure of the dam occur, is estimated to be four miles.

A review of available data did not disclose that seepage and stability analyses of the dam were performed. This is considered a deficiency and should be rectified.

It is recommended that the Owner take the necessary action, without delay, to correct the safety defects and deficiencies reported herein.

Albert B. Becker, Jr.
P.E. Missouri E-9168

OVERVIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
ALFRED B. BUHL, JR. LAKE DAM - ID NO. 30464

TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

LIST OF PLATES

APPENDIX

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
ALFRED B. BUHL, JR. LAKE DAM - ID NO. 30464

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. National Dam Inspection Act, Public Law 92-367, dated 8 August 1972.

b. Purpose of Inspection. The purpose of this visual inspection was to make an assessment of the general condition of the dam with respect to safety and, based upon available data and this inspection, determine if the dam poses a hazard to human life or property.

c. Evaluation Criteria. This evaluation was performed in accordance with the "Phase I" investigation procedures as prescribed in "Recommended Guidelines for Safety Inspection of Dams," Appendix D to "Report of the Chief of Engineers on the National Program of Dams," dated May 1975.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances. The Buhl Lake Dam is an earth-fill type embankment rising approximately 37 feet above the original stream bed. A 20 foot wide berm is located on the downstream slope about 5 feet below the top of dam. Lake level is governed by an excavated earth type spillway section located adjacent to the right (looking downstream) abutment. The spillway is grass covered. The outlet channel below the spillway crest is in earth and is badly eroded. At normal pool, the lake surface occupies approximately 6 acres. There are no drawdown facilities for dewatering the lake.

b. Location. The dam and lake are located on an unnamed tributary of La Barque Creek, approximately 4.5 miles southeast of Pacific, Missouri, in Jefferson County, as shown on the Regional Vicinity Map, Plate 1. The dam is located in Sectons 32 and 33, Township 43 North, Range 3 East, approximately 1 mile west of the intersection of State Routes F and FF.

c. Size Classification. The size classification based on the height of the dam and storage capacity is categorized as small. (Per Table 1, Recommended Guidelines for Safety Inspection of Dams.)

d. Hazard Classification. The Buhl Lake Dam, according to the St. Louis District, Corps of Engineers, has a high hazard potential, meaning that the dam is located where failure may cause loss of life, serious damage to homes, extensive agricultural, industrial and commercial facilities, important public utilities, main highways, or railroads. The estimated flood damage zone, should failure of the dam occur, as determined by the St. Louis District, extends four miles downstream of the dam. Within the possible damage zone are three homes and one county road bridge.

e. Ownership. The lake and dam are owned by Mr. Alfred B. Buhl, Jr., Lakewood Hills, Pacific, Missouri, 63069.

f. Purpose of Dam. The dam impounds water for the purpose of private recreation.

g. Design and Construction History. The dam was constructed in 1953 by the former owners of the property, Mr. and Mrs. Samuel C. Mittelberg. According to information provided by Mrs. Mittelberg, the builder of the dam was a Mr. William Eastwood, a local contractor, experienced in construction of small, earthfill dams. Mr. Eastwood's present location and status are unknown. In 1970, the property was sold to Messrs John L. Overman, Jr., and Alfred B. Buhl, Jr., who became joint owners of the lake and dam. Subsequently, Mr. Buhl purchased the interest of Mr. Overman and became the sole owner.

h. Normal Operational Procedure. The lake level is unregulated.

1.3 PERTINENT DATA

a. Drainage Areas. The area tributary to the lake is virtually undeveloped and in a natural state covered with timber. At one time, the present owner proposed to develop the area about the lake for residental usage, but has since abandoned the plan. The watershed above the dam amounts to approximately 76 acres. The watershed area is outlined on Plate 1.

b. Discharge at Damsite.

(1) Estimated maximum flood at damsite... Unknown

(2) Spillway capacity ... 20 cfs

c. Elevation (ft above MSL). The lake water surface at the time of inspection was assumed to be elevation 590. The basis of this assumption being the contours, at 10-foot intervals, shown on the 1954 Pacific Missouri Quadrangle Map, 7.5 minute series, photo revised 1968.

(1) Top of dam ... 591.1 (min.)

(2) Normal pool (spillway crest) ... 590.6

(3) Streambed at centerline of dam ... 552.8

(4) Maximum tailwater ... Unknown

d. Reservoir.

(1) Length of normal pool (elevation 590.6) ... 1,100 ft.

(2) Length of maximum pool (elevation 591.1) ... 1,200 ft.

e. Storage.

(1) Normal pool... 81 ac. ft.

(2) Top of dam (incremental) ... 3 ac. ft.

f. Reservoir Surface.

(1) Top of dam ... 7 acres

(2) Normal pool ... 6 acres

g. Dam.

(1) Type ... Earthfill

(2) Length ... 540 ft.

(3) Height ... 37 ft.

(4) Top Width ... 10 ft.

(5) Side Slopes

(a) Upstream ... 1v on 3h

(b) Downstream ... 1v on 2.6h (upper), 1v on 2.6h (lower)(1)

(6) Cutoff ... Earthfill Trench (per original owner)

(7) Slope Protection

(a) Upstream ... None

(b) Downstream ... Grass

h. Spillway ... Excavated earth, grass covered.

i. Outlet for Lake Drawdown ... None provided.

(1) 20 ft. wide berm at elevation 585.0±.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No engineering data relating to the design of the dam is known to exist.

2.2 CONSTRUCTION

No formal records were kept during construction of the dam. Mrs. Mittleberg, owner of the property during the time when the dam was constructed, reported that a trench was excavated to bedrock along the alignment of the dam and that the rock was drilled and tested, presumably for soundness. Subsequently, the trench was backfilled with clay and the embankment constructed. A sheepsfoot roller was used to compact the fill. Materials used to construct the earthfill dam were obtained from the area to be occupied by the lake.

2.3 OPERATION

It was reported by Mr. Overman, a former owner, that the dam was overtopped sometime about 4 years ago and that lake water came over the top of the dam for a period of about 2 hours. According to Mr. Overman, no significant damages occurred as a result of the dam being overtopped. The lake level is governed by an uncontrolled, excavated earth spillway.

2.4 EVALUATION

(a) Availability. Engineering data for assessing the design of the earthfill dam and spillway was unavailable.

(b) Adequacy. No data available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the dam and spillway was made by Horner & Shifrin engineering personnel on 29 June 1978. Also inspected at this time was the area downstream from the dam including the juncture of the tributary with La Barque Creek and the various downstream road crossings and houses between the dam and the Meramec River. Photographs of the dam taken at the time of the inspection are included on Pages A-1 and A-2 of the Appendix.

b. Dam. The visible portions of the upstream and downstream slopes (See Photos 1, 3 and 4) of the dam appeared to be in satisfactory condition with the exception of some minor erosion of the downstream slope at the toe near the center of the dam. Several holes that appeared to be animal burrows were observed in the crest of the dam. The extent of these burrows was not determined. A heavy cover of small- and medium-sized trees and brush exists on the downstream slope. The growth almost competely covered the slope between the berm near the dam crest and the valley floor. Some seepage, estimated to be 1-2 gpm where it was flowing in the stream course, was also noticed at the downstream toe of slope near the center of the dam.

The elevation of the top of the dam, as determined by survey, was found to be approximately 1.4 feet lower at a location near the center of the dam than the top of the dam in the area adjacent to the spillway. Also, the elevation of the spillway crest was determined by survey to be about 0.5 foot lower than the low point of the dam. A profile of the dam crest centerline is shown on Plate 2.

c. Spillway. The crest area of the excavated earth spillway section was found to be in satisfactory condition with a substantial turf (See Photo 2) cover. The spillway outlet channel, beginning at a point about 70 feet downstream from the control point, was unimproved and noticeably eroded. The spillway outlet channel joins the stream course at a point about 300 feet below the dam. A profile of the spillway centerline through the control section is shown on Plate 2.

d. Downstream Channel. The downstram channel is unimproved. The stream joins La Barque Creek at a point approximately 1,800 feet below the dam. La Barque Creek joins the Meramec River approximately 4 miles below the dam.

3.2 EVALUATION

The deficiencies observed during this inspection, with the exception of the apparent settlement of the dam and the effect thereof on the capacity of the spillway and its ability to discharge lake outflow at the volume required to prevent overtopping of the dam, are not considered of major consequence to warrant immediate remedial action. The entire downstream slope of the dam should be re-examined to determine its condition after removal of the heavy cover of trees and brush. Care should be taken not to destroy the existing turf cover when this clearing work is performed.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The spillway is uncontrolled. The water surface level is governed by rainfall runoff, evaporation, seepage, and the capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM AND SPILLWAY

Based on the extensive cover of trees and vegetation on the downstream slope of the dam, it is apparent that this area receives little attention. According to the owner, the grass on the dam crest is mowed occasionally. However, there is no established maintenance program for either the dam or spillway.

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

No outlet operating facilities exist at this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEMS IN EFFECT

The inspection did not reveal the existence of a dam warning system.

4.5 EVALUATION

Poor maintenance is considered detrimental to the safety of the dam. It is recommended that maintenance on a regular basis of the dam and spillway be undertaken.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data is not available.

b. Experience Data. The drainage area and lake surface area were developed from the USGS Pacific, Missouri Quadrangle Map. The proportions and dimensions of the spillway and dam were developed from surveys made during the inspection.

c. Visual Observations.

(1) The crest of the excavated earth spillway section is in good condition. Considerable erosion is evident in the grass lined earth outlet channel beginning at a point about 70 feet downstream of the crest control point.

(2) Drawdown facilities are not provided to dewater the lake.

(3) The spillway and outlet channel are located in the right abutment of the dam. Spillway releases, within the limited capacity of the spillway section, will not endanger the integrity of the dam.

d. Overtopping Potential. The spillway section is too small to pass the probable maximum flood, the 1/2 probable maximum flood, or the 1 percent chance (100-year frequency) flood without overtopping the dam. The results of a dam overtopping analysis are as follows:

Ratio of PMF	Q - Peak Outflow (cfs)	Max. Lake Water Surface Elev.	Max. Depth of Flow Over Dam (Elev. 591.1)	Duration of Overtopping of Dam (Hours)
0.05	20	591.1	0	0
0.5	840	592.4	1.3	9.9
1.0	1,774	592.9	1.8	14.3
100-Year Flood	352	591.9	0.8	3.2

The flow safely passing the spillway just prior to overtopping amounts to about 20 cfs, which is the outflow corresponding to about 5 percent of the probable maximum flood inflow, but less than the 1 percent chance (100-year frequency) flood.

Procedures and data for determining the probable maximum flood, the 100-year frequency flood, and the discharge rating curve for flow over the spillway and the dam crest are presented on Pages B-1 and B-2 of the Appendix. A listing of the HEC-1DB input data is shown on Pages B-3 through B-5 of the Appendix.

SECTION 6 - STRUCTURAL STABILITY

6.1. EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations which adversely affect the structural stability of the dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. No design or construction data relating to the structural stability of the dam are know to exist.

c. Operating Records. No appurtenant structurers or facilities requiring operation exist at this dam. According to the owner, no records have been kept of lake level, spillway discharge, dam settlement, or seepage.

d. Post Construction Changes. According to the present and former owners, post construction changes were not made which will affect the structural stability of the dam.

e. Seismic Stability. Since the dam is located within a Zone II seismic probability area, an earthquake of the magnitude predicted is not expected to produce a hazardous condition to the dam, provided that static stability conditions are satisfactory and conventional safety margins exist.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. A hydraulic analysis indicated the excavated earth spillway to be capable of passing lake outflow of about 20 cfs without the level of the lake exceeding the low point in the top of the dam. A hydrologic analysis of the lake watershed area, as discussed in Section 5, paragraph 5.1d., indicated that for a storm runoff of one-half maximum probable flood magnitude, the lake outflow would be on the order of 840 cfs, and that for the 1 percent chance (100-year frequency) flood, the lake outflow would be about 352 cfs.

Several items were noticed during the visual inspection that adversely affect the safety of the dam. These items, which exist on the downstream slope, are seepage, trees, dense brush, and surface erosion. The extent of the effect of these items can be better assessed after the trees and brush are removed. The holes believed to be animal burrows observed in the crest and upstream face of the dam are also considered detrimental to the safety of the dam since these voids provide pathways for seepage.

No stability and seepage analyses of the dam are known to exist.

b. Adequacy of Information. Due to the lack of engineering and construction data, the assessments reported herein were based on external conditions as determined during the visual inspection. Those recommendations with regard to the hydrology of the lake and the capacity of the spillway were based on a brief hydrologic-hydraulic study.

c. Urgency. The safety defects noted in paragraph 7.1a regarding the limited capacity of the spillway section should be investigated without delay since failure of the dam, regardless of past performance during overtopping, could result from overtopping. The quantity of seepage flow observed in the

stream near the dam toe of slope is not considered to be significant, however, it is recommended that this flow be monitored in the future in order to determine if the condition is steady or gaining. The remaining items concerning the safety of the dam and the remedial measures recommended in paragraph 7.2 should be accomplished in the near future.

d. Necessity for Phase II. Based on the results of the Phase I inspection, a Phase II investigation is not recommended.

e. Seismic Stability. Since the dam is located within a Zone II seismic probability area, an earthquake of the magnitude predicted is not expected to produce a hazardous condition to the dam, provided that static stability conditions are satisfactory and conventional safety margins exist.

7.2 REMEDIAL MEASURES

a. Recommendations. The following actions are recommended:

(1) Spillway size and/or height of dam should be increased to pass lake outflow resulting from a storm of at least one-half probable maximum flood magnitude.

(2) It is recommended that the low area located near the center of the dam be raised such that it no longer governs spillway capacity. Since the low area at the center of the dam is considered to be a result of settlement due to consolidation of the embankment and foundation soils, and since it is not known if all or nearly all of the settlement that is obtainable has taken place (the dam is about 25 years old), it is recommended that settlement (future) of the dam be monitored in order to determine overtopping potential and conditions affecting the operation of the spillway.

(3) Obtain the necessary soil data and perform stability and seepage analyses in order to determine the structural stability of the dam for all operational conditions.

b. O & M Maintenance and Procedures. The following O & M maintenance and procedures are recommended:

(1) Remove the trees and brush from the downstream slope of the dam. Tree roots provide a passageway for seepage and can lead to a piping condition and potential failure. The existing turf cover should be restored if destroyed or missing. Maintain the turf cover on the slope at a height that will not hinder inspection of the slope.

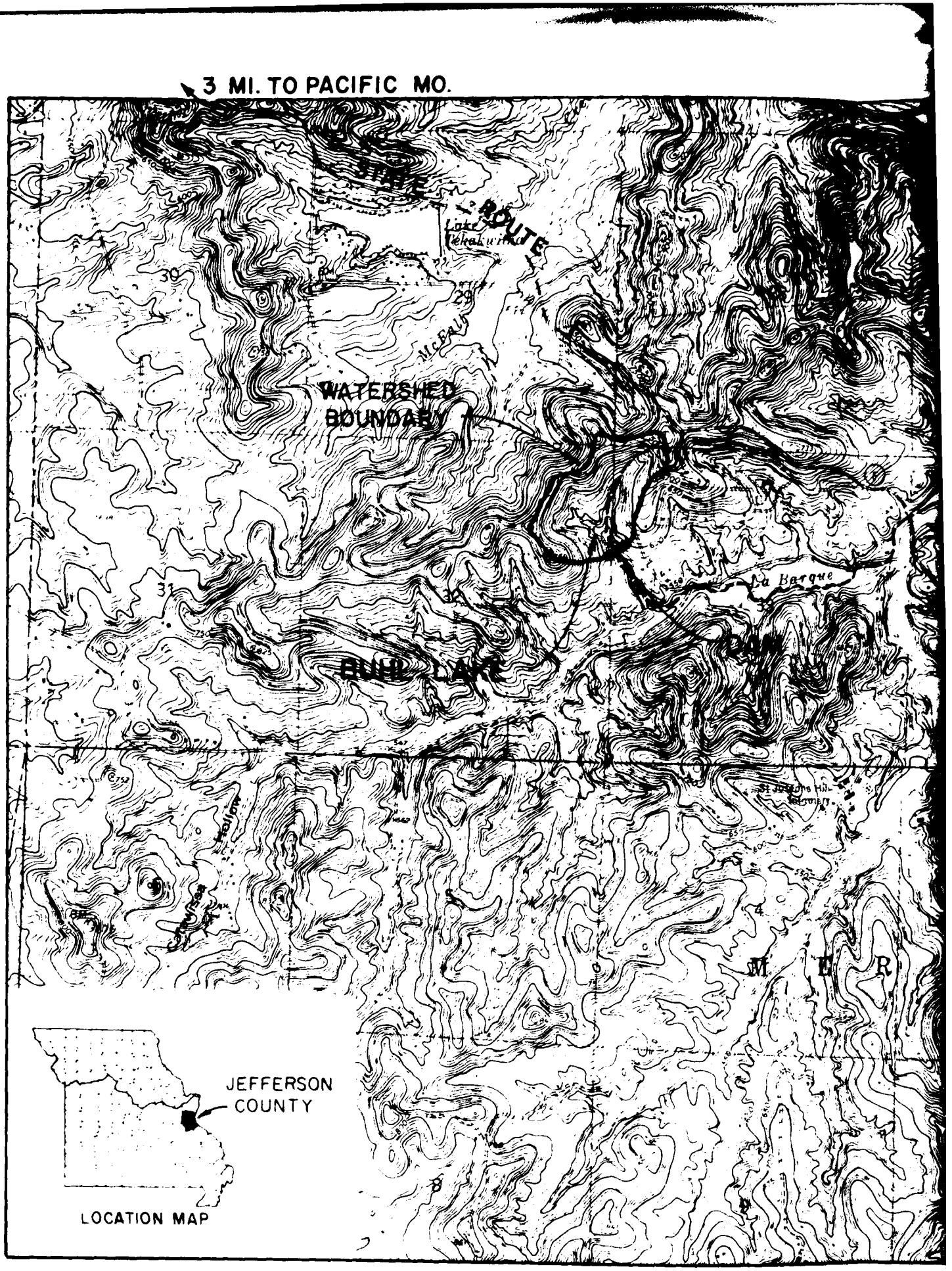
(2) Once the downstream slope is cleared of trees and brush, it should be thoroughly checked for seepage, erosion and other signs of instability. If excessive seepage flows are observed or sloughing noted, the dam should be investigated by an engineer experienced in design and construction of dams.

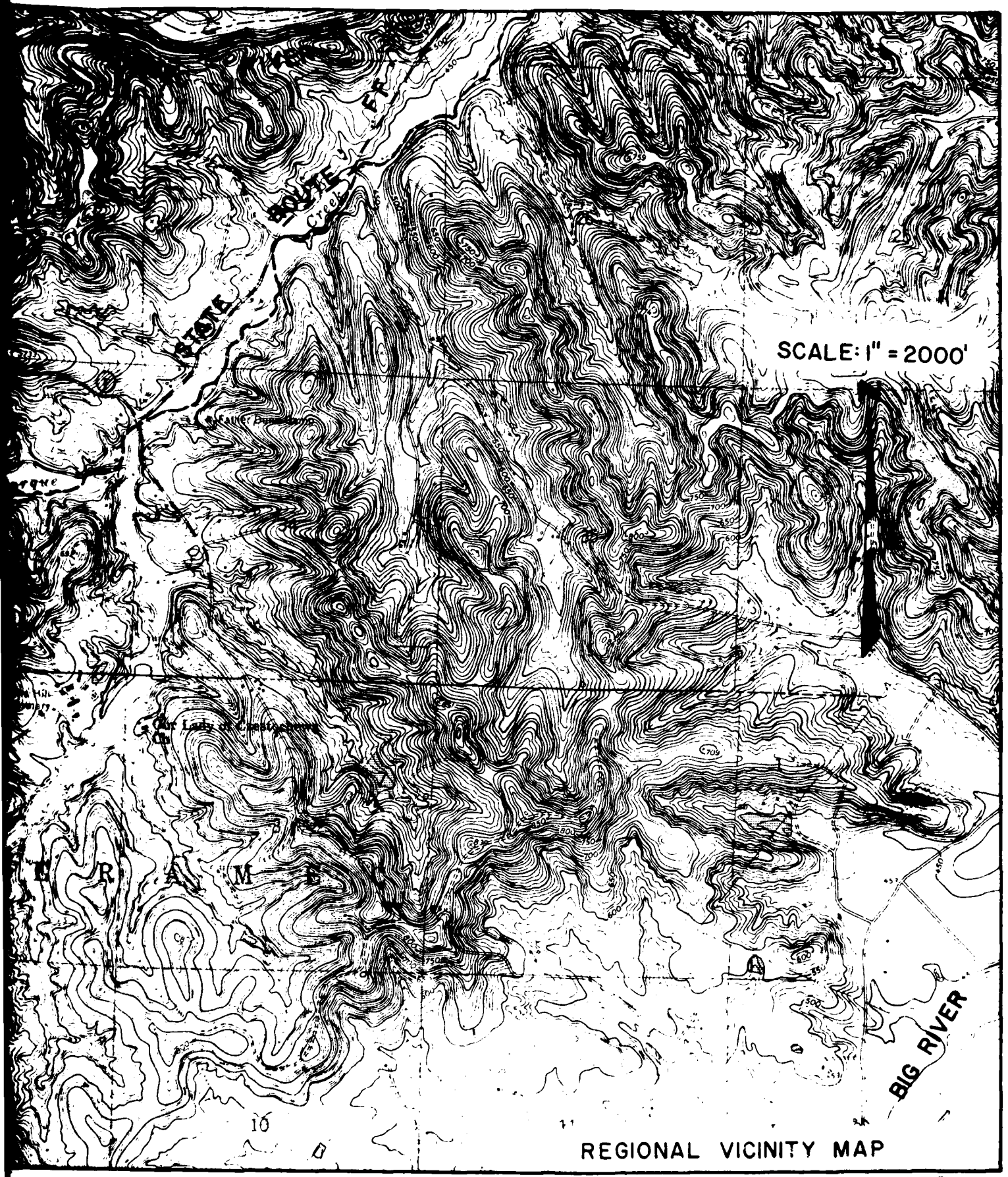
(3) Eliminate holes in dam, created by burrowing animals or by the removal of tree roots, in order to reduce the seepage potential and the possibility of a piping condition.

(4) Provide some form of protection for the spillway outlet channel in order to prevent back cutting by erosion of the spillway crest.

(5) Provide some form of slope protection for the upstream face of the dam in order to prevent erosion by wave action.

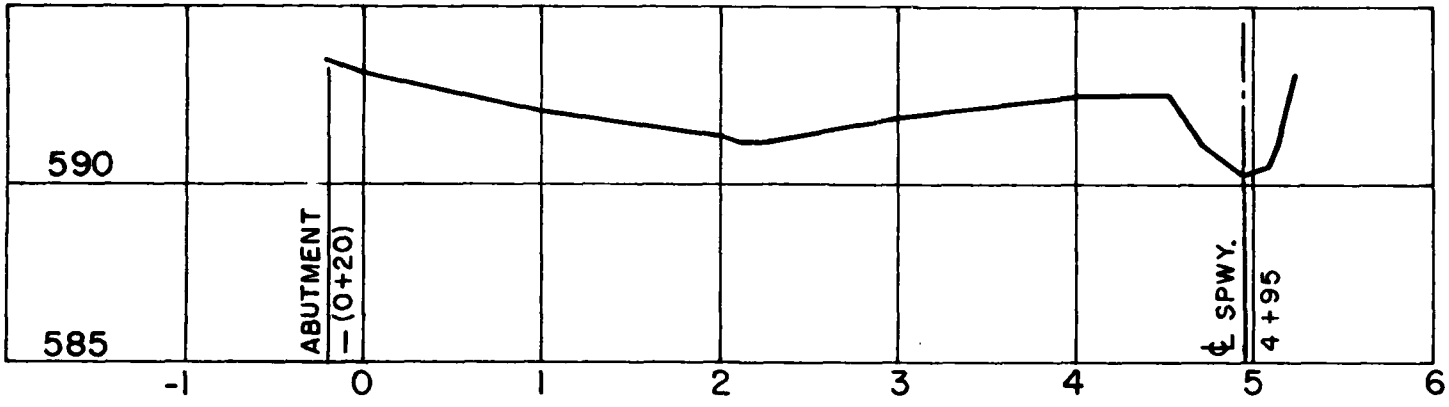
(6) A detailed inspection of the dam should be instituted on a regular basis by an engineer experienced in the design and construction of dams. It is also recommended, for future reference, that records be kept of all inspections and remedial measures.


3 MI. TO PACIFIC MO.
ROUTE
WATERSHED BOUNDARY
La Barque
JEFFERSON COUNTY
LOCATION MAP



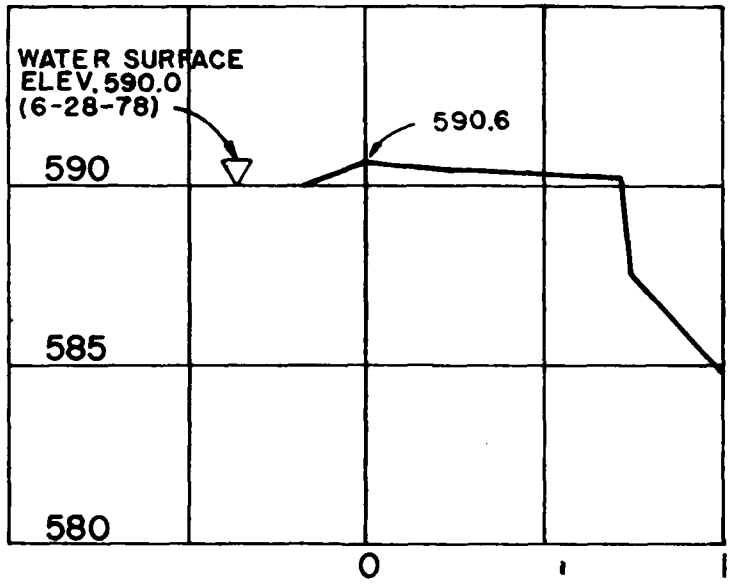
REGIONAL VICINITY MAP

PLATE 1



PROFILE DAM CREST

SCALES: 1"=5' V., 1"=100' H.



PROFILE SPILLWAY ℄

SCALES: 1"=5' V., 1"=50' H.

NOTE: STA. 0+00 ℄ DAM OPPOSITE LIGHT STANDARD, 6' RIGHT

BUHL LAKE

DAM & SPILLWAY PROFILES

Horner & Shifrin, Inc. July 1978

PLATE 2

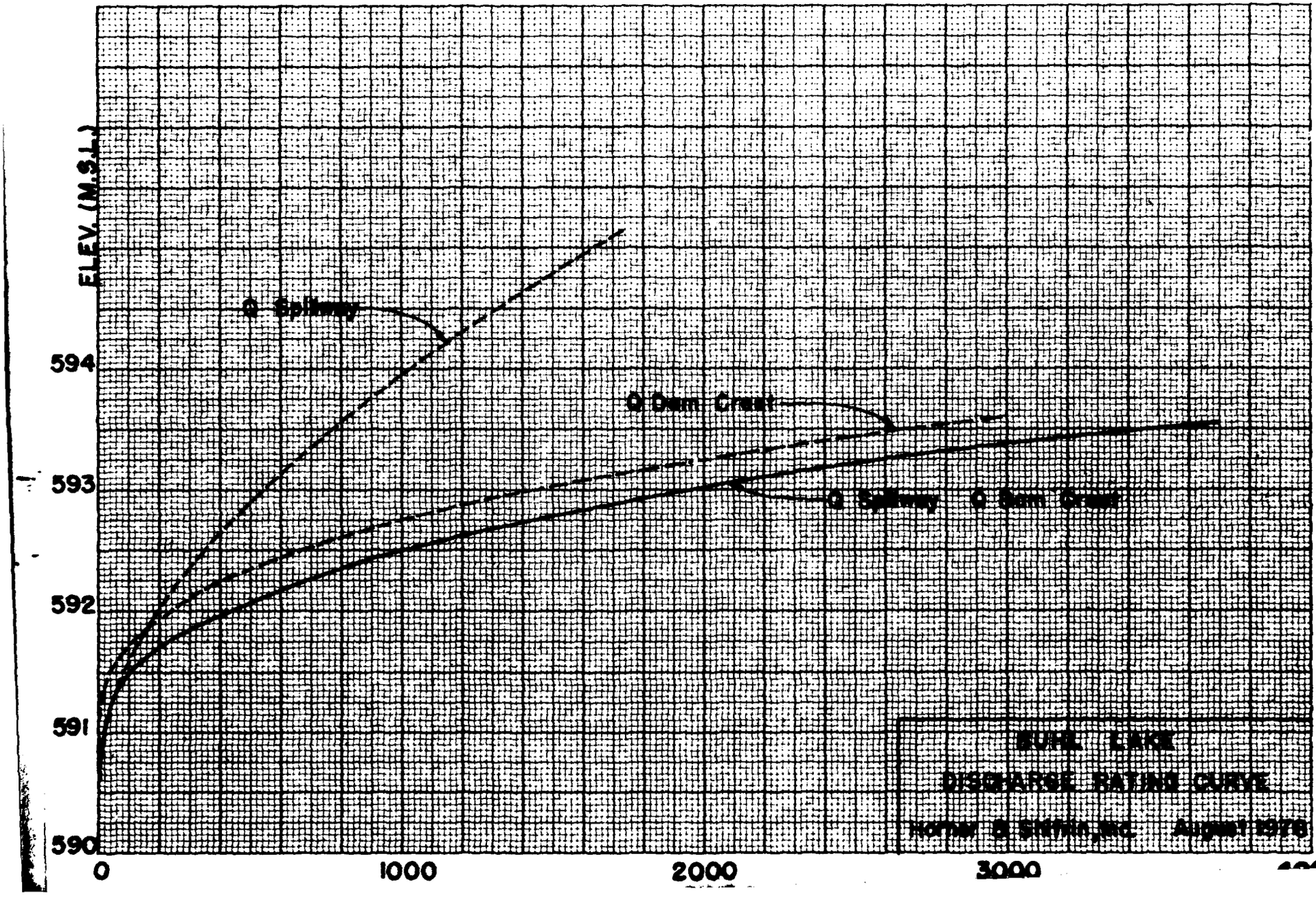
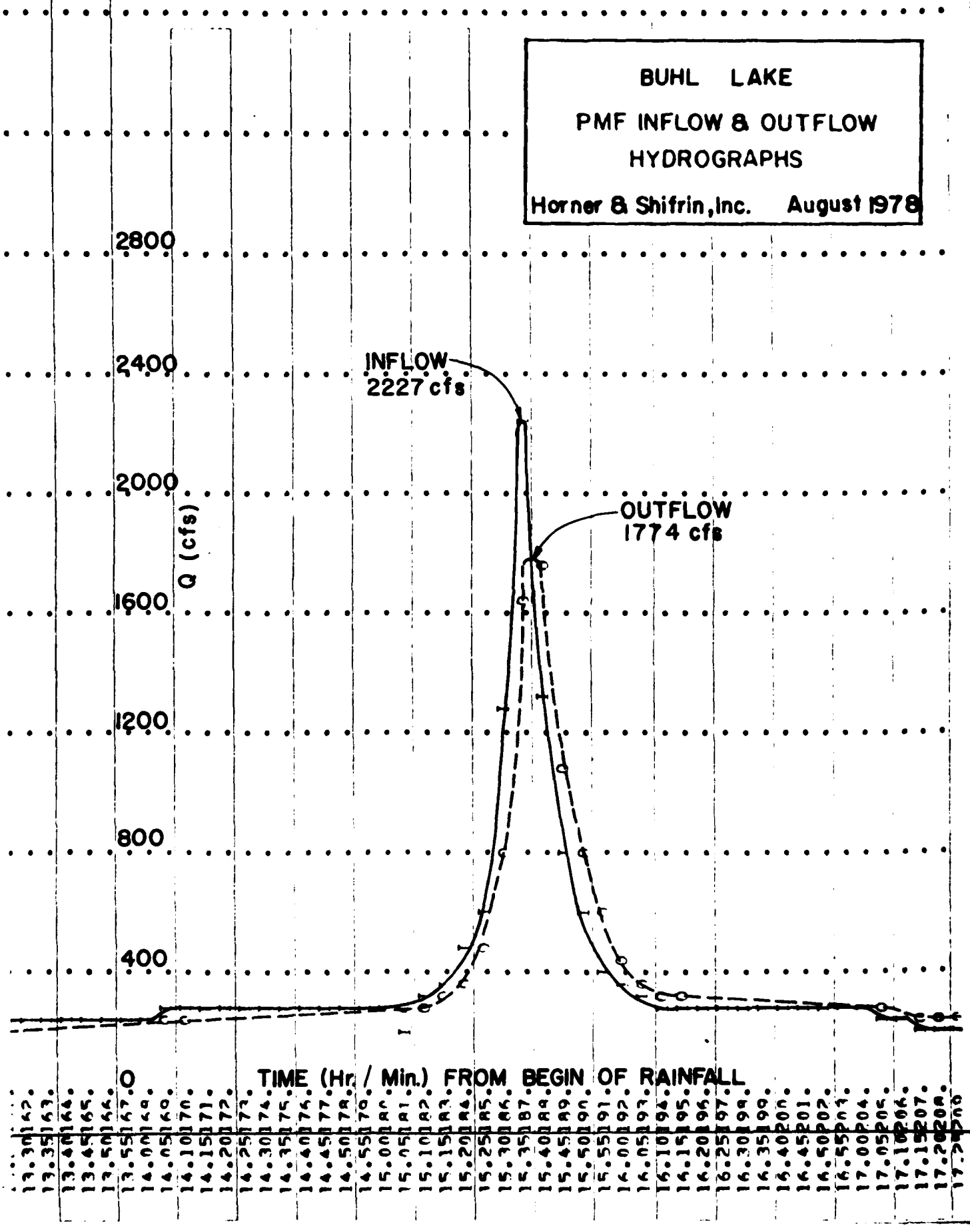

ELEV. (M.S.L.)
Q Spillway
Q Dam Crest
Q Spillway + Q Dam Crest
594
593
592
591
590
0
1000
2000
3000
BURR LAKE
DISCHARGE RATING CURVE
Horner & Shifrin, Inc. August 1978

PLATE 3

PLATE 4


BUHL LAKE
PMF INFLOW & OUTFLOW
HYDROGRAPHS
Horner & Shifrin, Inc. August 1978
2800
2400
2000
1600
1200
800
400
Q (cfs)
INFLOW
2227 cfs
OUTFLOW
1774 cfs
0
TIME (Hr. / Min.) FROM BEGIN OF RAINFALL

APPENDIX

NO. 1: UPSTREAM FACE OF DAM

NO. 2: EARTH SPILLWAY

NO. 3: DOWNSTREAM SLOPE ABOVE BERM

NO. 4: DOWNSTREAM SLOPE BELOW BERM

HYDROLOGIC COMPUTATIONS

1. The HEC-1 Dam Safety Version (July 1978) program was used to develop inflow and outflow hydrographs and dam overtopping analyses, with hydrologic inputs as follows:

a. Probable maximum precipitation (200 sq. mile, 24-hour value equals 25.4 inches) from Hydrometeorological Report No. 33. One hundred year frequency (point source precipitation, 24-hour value equals 7.23 inches) from U.S. Weather Bureau Technical Paper No. 40.

b. Drainage area = 0.12 square miles
= 76 acres

c. SCS parameters
Lag time = 0.04 hours
Soil type CN = 80

2. The spillway section consists of a broad-crested, approximately V-shaped earth section for which conventional weir formulas do not apply.

Spillway release rates were determined as follows:

(1) Spillway crest section properties (area, a and top width, T) were computed for various depths, d.

(2) It was assumed that flow leaving the spillway crest would occur at critical depth. Flow at critical depth (Q_c) was computed as $Q_c = \left(\frac{a^3}{t}\, g\right)^{0.5}$ for the various depth, d.

Corresponding velocities (v_c) and velocity heads (H_{vc}) were determined using conventional formulas.

(3) Static lake levels corresponding to the various Q_c values passing over the spillway were computed as critical depths plus critical velocity head ($d_c + H_{vc}$), and the relationship between lake level and spillway discharge was thus obtained. The procedure neglects the minor insignificant friction losses across the length of the spillway.

3. The profile of the dam crest is irregular and flow over the dam crest cannot be determined by conventional weir formulas. Flow quantities overtopping the dam crest were computed as described in the preceding paragraph and corresponding flow over the dam and spillway for given elevations were added to obtain the combined outflow rating curve for the dam and spillway. This rating curve is shown on Plate 3. The inflow and outflow hydrographs for the PMF are shown on Plate 4.

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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  3 AUG 78
**********
    1                 A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
    2                 A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF BUHL LAKE DAM
    3                 A3       RATIOS OF PMF ROUTED THROUGH RESERVOIR
    4                 R     288        0        5       -0       -0       -0       -0       -0       -0       -0
    5                 R1      5
    6                 J       1        3        1
    7                 J1   0.05     0.50     1.00
    8                 K       0   INFLOW                                          3        1
    9                 K1       INFLOW HYDROGRAPH
   10                 M       1        2    0.12                          1.0                                1
   11                 P       0     25.4      102      120      130
   12                 T                                                                -1      -80
   13                 W2              0.04
   14                 X    -1.0     -.10      2.0
   15                 K       1      DAM                                2        3        1
   16                 K1       RESERVOIR ROUTING BY MODIFIED PULS
   17                 Y                                          1        1
   18                 Y1      1                                                        R1       -1
   19                 Y4  590.5    591.1    591.5    591.8      592    592.5      593    593.5
   20                 Y5      0       20      100      260      420     1000     1970     3480
   21                 SA      0      6.3     11.5     17.5
   22                 SF    552    590.6      600      610
   23                 SS  590.6
   24                 SD  591.1
   25                 K      00
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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  3 AUG 78
**********
     1                A1       ANALYSIS OF DAM OVERTOPPING USING 100 YR FLOOD
     2                A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF RUHL LAKE DAM
     3                A3       100 YR FLOOD ROUTED THROUGH RESERVOIR
     4                B    288        0        5       -0       -0       -0       -0       -0       -0       -0
     5                J1     5
     6                J     1         1        1
     7                J1   1.0
     8                K       1  INFLOW                                  3        1
     9                K1       INFLOW HYDROGRAPH
    10                K     1         2    0.12                          1.0                1
    11                K     288
    12                K1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
    13                K1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
    14                K1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
    15                K1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
    16                K1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
    17                K1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
    18                K1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
    19                K1  .007     .007     .014     .014     .014     .014     .014     .014     .014     .014
    20                K1  .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
    21                K1  .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
    22                K1  .014     .014     .014     .014     .014     .014     .014     .014     .022     .022
    23                K1  .022     .022     .022     .022     .022     .022     .022     .022     .022     .022
    24                K1  .022     .022     .022     .022     .022     .022     .031     .031     .031     .031
    25                K1  .031     .031     .061     .061     .061     .061     .061     .061     .132     .132
    26                K1  .132     .253     .253     .555     .930     .395     .253     .132     .132     .132
    27                K1  .061     .061     .061     .061     .061     .061     .031     .031     .031     .031
    28                K1  .031     .031     .022     .022     .022     .022     .022     .022     .022     .022
    29                K1  .022     .022     .022     .022     .022     .022     .022     .022     .022     .022
    30                K1  .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
    31                K1  .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
    32                K1  .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
    33                K1  .014     .014     .014     .014     .014     .014     .007     .007     .007     .007
    34                K1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
    35                K1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
    36                K1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
    37                K1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
    38                K1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
    39                K1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
```

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39          O1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
40          O1   .007    .007    .007    .007    .007    .007    .007    .007
41          T                                                    -1      -80
42          NP          0.04
43          X    -1.0    -.10     2.0
44          K       1    084                         2       3       1
45          K1      RESERVOIR ROUTING BY MODIFIED PULS
46          Y                                   1       1
47          Y1      1                                                A1      -1
48          Y4  590.6   591.1   591.5   591.8     592     592.5     593     593.5
49          Y5      0      20     100     260     420      1000    1970     3480
50          SA      0     6.3    11.5    17.5
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B-5

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51          SE    552   590.6     600     610
52          SS  590.6
53          SD  591.1
54          K     99
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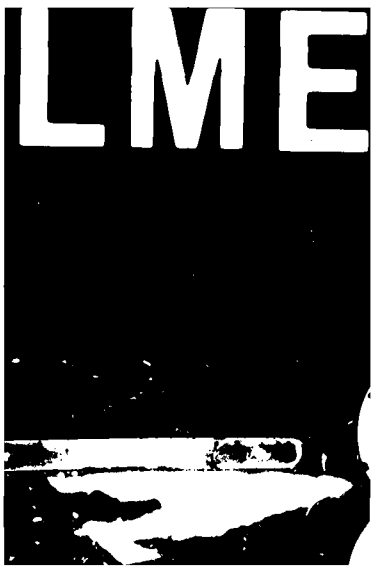
LME