AD-A105 349 ANDERSON ENGINEERING INC SPRINGFIELD MO F/G 13/13
NATIONAL DAM SAFETY PROGRAM. DEEL LAKE DAM (MO 31064), WHITE BA--ETC(U)
DEC 79 J M HEALY, G R WERTEPNY, D KERNS DACW43-79-C-0070

UNCLASSIFIED NL

1 OF 1
AD
A105349

END
DATE
FILMED
10-81
DTIC

AD A105349

LEVEL II

WHITE BASIN

DEEL LAKE DAM

SHANNON COUNTY, MISSOURI

MO 31064

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

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

FOR: STATE OF MISSOURI

DECEMBER 1979

81 10 9 071

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO. AD-A105349

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
Phase I Dam Inspection Report
National Dam Safety Program
Deel Lake Dam (MO 31064)
Shannon County, Missouri

9

5. TYPE OF REPORT & PERIOD COVERED
Final Report,

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Anderson Engineering, Inc.

15

8. CONTRACT OR GRANT NUMBER(s)
DACW43-79-C-0070

9. PERFORMING ORGANIZATION NAME AND ADDRESS
U.S. Army Engineer District, St. Louis
Dam Inventory and Inspection Section, LMSED-PD
210 Tucker Blvd., North, St. Louis, Mo. 63101

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11

11. CONTROLLING OFFICE NAME AND ADDRESS
U.S. Army Engineer District, St. Louis
Dam Inventory and Inspection Section, LMSED-PD
210 Tucker Blvd., North, St. Louis, Mo. 63101

12. REPORT DATE
Dec[redacted]79

13. NUMBER OF PAGES
Approximately 40

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

6

National Dam Safety Program. Deel Lake Dam (MO 31064), White Basin, Shannon County, Missouri. Phase I Inspection Report.

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

12

57

16. DISTRIBUTION STATEMENT (of this Report)

Approved for release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

1981

A

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.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

412554

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

INSTRUCTIONS FOR PREPARATION OF REPORT DOCUMENTATION PAGE

RESPONSIBILITY. The controlling DoD office will be responsible for completion of the Report Documentation Page, DD Form 1473, in all technical reports prepared by or for DoD organizations.

CLASSIFICATION. Since this Report Documentation Page, DD Form 1473, is used in preparing announcements, bibliographies, and data banks, it should be unclassified if possible. If a classification is required, identify the classified items on the page by the appropriate symbol.

CO''PLETION GUIDE

General. Make Blocks 1, 4, 5, 6, 7, 11, 13, 15, and 16 agree with the corresponding information on the report cover. Leave Blocks 2 and 3 blank.

Block 1. Report Number. Enter the unique alphanumeric report number shown on the cover.

Block 2. Government Accession No. Leave Blank. This space is for use by the Defense Documentation Center.

Block 3. Recipient's Catalog Number. Leave blank. This space is for the use of the report recipient to assist in future retrieval of the document.

Block 4. Title and Subtitle. Enter the title in all capital letters exactly as it appears on the publication. Titles should be unclassified whenever possible. Write out the English equivalent for Greek letters and mathematical symbols in the title *(see "Abstracting Scientific and Technical Reports of Defense-sponsored RDT/E,"AD-667 000)*. If the report has a subtitle, this subtitle should follow the main title, be separated by a comma or semicolon if appropriate, and be initially capitalized. If a publication has a title in a foreign language, translate the title into English and follow the English translation with the title in the original language. Make every effort to simplify the title before publication.

Block 5. Type of Report and Period Covered. Indicate here whether report is interim, final, etc., and, if applicable, inclusive dates of period covered, such as the life of a contract covered in a final contractor report.

Block 6. Performing Organization Report Number. Only numbers other than the official report number shown in Block 1, such as series numbers for in-house reports or a contractor/grantee number assigned by him, will be placed in this space. If no such numbers are used, leave this space blank.

Block 7. Author(s). Include corresponding information from the report cover. Give the name(s) of the author(s) in conventional order *(for example, John R. Doe or, if author prefers, J. Robert Doe)*. In addition, list the affiliation of an author if it differs from that of the performing organization.

Block 8. Contract or Grant Number(s). For a contractor or grantee report, enter the complete contract or grant number(s) under which the work reported was accomplished. Leave blank in in-house reports.

Block 9. Performing Organization Name and Address. For in-house reports enter the name and address, including office symbol, of performing activity. For contractor or grantee reports enter the name and address of the contractor or grantee who prepared the rep. . and identify the appropriate corporate division, school, laboratory, etc., of the author. List city, state, and ZIP Code.

Block 10. Program Element, Project, Task Area, and Work Unit Numbers. Enter here the number code from the applicable Department of Defense form, such as the DD Form 1498, "Research and Technology Work Unit Summary" or the DD Form 1634. "Research and Development Planning Summary," which identifies the program element, project, task area, and work unit or equivalent under which the work was authorized.

Block 11. Controlling Office Name and Address. Enter the full, official name and address, including office symbol, of the controlling office. *(Equates to funding/sponsoring agency. For definition see DoD Directive 5200.20, "Distribution Statements on Technical Documents.")*

Block 12. Report Date. Enter here the day, month, and year or month and year as shown on the cover.

Block 13. Number of Pages. Enter the total number of pages.

Block 14. Monitoring Agency Name and Address *(if different from Controlling Office)*. For use when the controlling or funding office does not directly administer a project, contract, or grant, but delegates the administrative responsibility to another organization.

Blocks 15 & 15a. Security Classification of the Report: Declassification/Downgrading Schedule of the Report. Enter in 15 the highest classification of the report. If appropriate, enter in 15a the declassification/downgrading schedule of the report, using the abbreviations for declassification/downgrading schedules listed in paragraph 4-207 of DoD 5200.1-R.

Block 16. Distribution Statement of the Report. Insert here the applicable distribution statement of the report from DoD Directive 5200.20, "Distribution Statements on Technical Documents."

Block 17. Distribution Statement *(of the abstract entered in Block 20, if different from the distribution statement of the report)*. Insert here the applicable distribution statement of the abstract from DoD Directive 5200.20, "Distribution Statements on Technical Documents."

Block 18. Supplementary Notes. Enter information not included elsewhere but useful, such as: Prepared in cooperation with . . . ranslation of *(or by)* . . . Presented at conference of . . . To be published in . . .

Block 19. Key Words. Select terms or short phrases that identify the principal subjects covered in the report, and are sufficiently specific and precise to be used as index entries for cataloging, conforming to standard terminology. The DoD "Thesaurus of Engineering and Scientific Terms" *(TEST)*, AD-672 000, can be helpful.

Block 20. Abstract. The abstract should be a brief *(not to exceed 200 words)* factual summary of the most significant information contained in the report. If possible, the abstract of a classified report should be unclassified and the abstract to an unclassified report should consist of publicly- releasable information. If the report contains a significant bibliography or literature survey, mention it here. For information on preparing abstracts see "Abstracting Scientific and Technical Reports of Defense-Sponsored RDT&E," AD-667 000.

☆ U.S. G.P.O. 1980-665-141/1299

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

REPLY TO
ATTENTION OF

SUBJECT: Deel Lake Dam (MO 31064) Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Deel Lake Dam (MO 31064).

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

SUBMITTED BY: SIGNED — Chief, Engineering Division — 27 MAR 1980 Date

APPROVED BY: SIGNED — Colonel, CE, District Engineer — 31 MAR 1980 Date

DEEL LAKE DAM

SHANNON COUNTY, MISSOURI

MISSOURI INVENTORY NO. 31064

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By

Anderson Engineering, Inc., Springfield, Missouri
Hanson Engineers, Inc., Springfield, Illinois

Under Direction Of

St. Louis District, Corps of Engineers

For

Governor of Missouri

March 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Deel Lake Dam
State Located:	Missouri
County Located:	Shannon
Stream:	Millman Hollow (Tributary to Shawnee Creek)
Date of Inspection:	24 September 1979

Deel Lake Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately two miles downstream of the dam. Located within this zone are four dwellings and one road. The dam is in the intermediate size classification, since it is greater than 40 ft high but less than 100 ft high.

Our inspection and evaluation indicates that the combined spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The combined spillways will pass 74 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of intermediate size with a high downstream hazard potential pass the PMF. The 100-year flood will not overtop the dam. The 100-year flood is one that has a 1 percent chance of being equaled or exceeded in any given year.

Deficiencies visually observed by the inspection team were: (1) some minor erosion at north abutment-dam contact; (2) lack of wave protection for upstream face of dam; (3) minor seepage beyond the embankment toe in the old streambed and from the embankment at Sta. 2+80; and (4) lack of non-erodible control sections for the primary spillway. Another deficiency was the lack of seepage and stability analysis records.

It is recommended that the owners take the necessary action in the near future to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.

Jack M. Healy

Jack M. Healy, P.E. (HEI)

Gene R. Wertepny

Gene R. Wertepny, P.E. (HEI)

Danny L Kerns

Dan Kerns, E.I.T. (HEI)

Steve Brady

Steve Brady, P.E. (AEI)

Tom Beckley

Tom Beckley, P.E. (AEI)

AERIAL VIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
DEEL LAKE DAM - ID No. 31064

TABLE OF CONTENTS

Paragraph No.	Title	Page No.
	SECTION 1 - PROJECT INFORMATION	
1.1	General	1
1.2	Description of the Project	1
1.3	Pertinent Data	3
	SECTION 2 - ENGINEERING DATA	
2.1	Design	7
2.2	Construction	8
2.3	Operation	9
2.4	Evaluation	9
	SECTION 3 - VISUAL INSPECTION	
3.1	Findings	10
3.2	Evaluation	11
	SECTION 4 - OPERATIONAL PROCEDURES	
4.1	Procedures	13
4.2	Maintenance of Dam	13
4.3	Maintenance of Operating Facilities	13
4.4	Description of Any Warning System in Effect	13
4.5	Evaluation	13
	SECTION 5 - HYDRAULIC/HYDROLOGIC	
5.1	Evaluation of Features	14
	SECTION 6 - STRUCTURAL STABILITY	
6.1	Evaluation of Structural Stability	15
	SECTION 7 - ASSESSMENT/REMEDIAL MEASURES	
7.1	Dam Assessment	16
7.2	Remedial Measures	17

APPENDICES

	Sheet
APPENDIX A	
Location Map	1
Vicinity Map	2
Plan, Profile and Section of Dam	3
Plan Sketch of Dam	4
APPENDIX B	
Geologic Regions of Missouri	1
Thickness of Loessial Deposits	2
Engineering Geologic Report	3-6
APPENDIX C	
Overtopping Analysis - PMF	1-7
APPENDIX D	
Photographs of Dam and Lake	1-7

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of Deel Lake Dam in Shannon County, Missouri.

B. Purpose of Inspection:

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

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

Deel Lake Dam is an earth fill structure approximately 41 ft high and 365 ft long at the crest. The appurtenant works consist of an earth swale primary spillway at the north end of the embankment, an earth swale emergency spillway at the south end of the embankment and a 6 in. diameter steel drawdown pipe with a valve located at the downstream toe of the embankment. Sheet 3 of Appendix A shows a plan profile and typical section of the embankment.

B. Location:

The dam is located in the southeast part of Shannon County, Missouri on Millman Hollow. The dam and lake are within the Winona, Missouri 7.5 minute quadrangle sheet

(Section 13, T28N, R4W - latitude 31° 05.95'; longitude 91° 20.33'). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 41 ft and a maximum storage capacity of approximately 296 acre-ft, the dam is in the intermediate size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has classified this dam as a high hazard dam. The estimated damage zone extends approximately two miles downstream of the dam. Located within this zone are four dwellings and one road.

E. Ownership:

The dam is owned by Mr. Robert Deel. The owner's address is Box 159, Eminence, Missouri 65466.

F. Purpose of Dam:

The dam was constructed primarily for recreational purposes.

G. Design and Construction History:

No design information is available, although the owner indicated that a Mr. Charlie Page drew some plans and did the surveying. The owner indicated that the dam was constructed in 1973 by Elmer Buxton of Ellington, Missouri. The owner indicated that a key trench was cut to bedrock and was from about 10 ft to 25 ft deep and 25 ft wide. The key trench reportedly was carried up the abutments. A core of select material was incorporated into the dam. Four seepage collars were provided for the 6 in. diameter steel dewatering pipe: one in the clay core, one in back of the core and two in front. These seepage collars were about 5 ft square.

Material for construction of the dam was obtained from the north and south valley walls upstream of the dam. In 1978, the crest of the embankment was widened about 4 ft.

H. Normal Operating Procedures:

The lake level is kept below the crest of the primary spillway by operating the 6 in. gate valve of the dewatering conduit. Every fall the lake level is lowered about 4 ft below the crest of the primary spillway to control weed growth in the lake.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 3 of Appendix A presents a plan, profile and typical section of the embankment.

A. Drainage Area:

The drainage area for this dam, as obtained from the U.S.G.S. quad sheet, is approximately 350 acres.

B. Discharge at Dam Site:

(1) All normal discharge at the dam site is through uncontrolled spillways. Some discharge can also occur through the drawdown pipe.

(2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 855.9): 3,995 cfs

(3) Estimated Capacity of Primary Spillway: 3,730 cfs

(4) Estimated Experienced Maximum Flood at Dam Site: 150 cfs

(5) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable

(6) Diversion Tunnel Outlet at Pool Elevation: Not Applicable

(7) Gated Spillway Capacity at Pool Elevation: Not Applicable

(8) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable

C. Elevations:

All elevations are consistent with an estimated M.S.L. elevation of 852.7 for the top of rock on centerline at Station 5+65 (see Sheet 3, Appendix A).

(1) Top of Dam: 855.9 (Low Point) 856.0 (High Point)

(2) Principal Spillway Crest: 849.8

(3) Emergency Spillway Crest: 853.1

(4) Principal Outlet Pipe Invert: Not Applicable

(5) Streambed at Centerline of Dam: 815.0

(6) Pool on Date of Inspection: 849.3

(7) Apparent High Water Mark: 851.0

(8) Maximum Tailwater: Unknown

(9) Upstream Portal Invert Diversion Tunnel: Not Applicable

(10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

(1) At Top of Dam: 2000 ft

(2) At Principal Spillway Crest: 1700 ft

(3) At Emergency Spillway Crest: 1850 ft

E. Storage Capacities:

(1) At Principal Spillway Crest: 187 acre-ft

(2) At Top of Dam: 296 acre-ft

(3) At Emergency Spillway Crest: 242 acre-ft

F. Reservoir Surface Areas:

(1) At Principal Spillway Crest: 16 acres

(2) At Top of Dam: 20.2 acres

(3) At Emergency Spillway Crest: 18.2 acres

G. Dam:

(1) Type: Earth

(2) Length at Crest: 365 ft

(3) Height: 41 ft

(4) Top Width: 26 ft

(5) Side Slopes: Upstream 1.8-2.4:1; Downstream 3.1-6.3:1 (See Sheet 3, Appendix A)

(6) Zoning: Select material upstream of clay core (from owner)

(7) Impervious Core: Yes (from owner)

(8) Cutoff: Key trench down to bedrock; 25 ft wide; 10 to 27 ft deep; carried up abutments (from owner)

(9) Grout Curtain: No

H. Diversion and Regulating Tunnel:

(1) Type: Not Applicable

(2) Length: Not Applicable

(3) Closure: Not Applicable

(4) Access: Not Applicable

(5) Regulating Facilities: Not Applicable

I. Spillway:

I.1 Principal Spillway:

(1) Location: North Abutment

(2) Type: Trapezoidal Cut on Natural Ground

I.2 Emergency Spillway:

(1) Location: South Abutment

(2) Type: Trapezoidal Cut on Natural Ground

J. Regulating Outlets:

The only regulatory facility associated with this dam is the 6 in. gated steel pipe dewatering structure which is used to regulate the pool level. It is possible to draw down the lake to within 2 ft of the bottom.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

No design computations or reports for Deel Lake Dam are available. No documentations of construction inspection records have been obtained. To our knowledge, there are no documented maintenance data.

A. Surveys:

A preconstruction survey was reportedly performed at the site. However, this survey information could not be obtained. Sheet 3 of Appendix A presents a plan, profile and cross section of the dam from survey data obtained from the site inspection. The top of a rock on ℄ Station 5+65 was used as a site datum of assumed elevation 100.00 (see Sheet 3, Appendix A). It is estimated that this site datum approximately corresponds to mean sea level elevation 852.7.

B. Geology and Subsurface Materials:

The site is located in the central portion of the Ozarks geologic region of Missouri. The Ozarks are characterized topographically by hills, plateaus and deep valleys. The most common bedrock types are dolomite, sandstone and chert.

Information supplied by the Missouri Geological Survey indicates that the bedrock in the valley is the Eminence Formation. This formation is composed principally of medium to massively bedded, light gray, medium- to coarse-grained dolomite. The Missouri Geological Survey reports that the Eminence in the site area is very badly weathered and pinnacled. In addition, much solution work has taken place on both the vertical joints and the horizontal bedding planes. Numerous small springs exist upstream and downstream of the dam. The publication "Caves of Missouri" indicates that there are about 18 caves known to exist in Shannon County. Of these caves and the ten caves listed in adjacent Carter County, four caves are within a 10 mile radius of the site.

The Geologic Map of Missouri indicates a normal fault passing about 16 miles northeast of the site in a general east-west direction. The Missouri Geological Survey has indicated that the faults in this area are generally considered to be inactive and have been for several hundred million years.

Soils in the area of the dam appear to be primarily Clarksville Stony Loam. The Clarksville series subsoil is a reddish-yellow to red silty clay to heavy, stiff, tenacious, compact clay. These residual soils are derived from cherty and dolomitic limestones. Chert fragments are very common in the Clarksville soils. The loessial thickness map indicates that upland areas have less than 2.5 ft of loess cover.

Additional information on the geology and subsurface materials in the site area can be found in the attached "Engineering Geologic Report" (Sheets 3 through 6 of Appendix B).

C. Foundation and Embankment Design:

The only foundation design information obtained is included in the Engineering Geologic Report prepared by the Missouri Geological Survey and presented in Sheets 3 through 6 of Appendix B. Site No. 1 discussed in the report was the one selected for this dam. No embankment design information was obtained. Seepage and stability analyses apparently were not performed as required in the guidelines. Reportedly, there is a key trench and clay core incorporated into the embankment. No internal drainage features are known to exist. No construction inspection test results have been obtained.

D. Hydrology and Hydraulics:

No hydrologic or hydraulic design computations for this dam were available. Based on a field check of spillway dimensions and embankment elevations and a check of the drainage area and U.S.G.S. quad sheets, hydrologic analyses using U.S. Army Corps of Engineers guidelines were performed and appear in Appendix C, Sheets 1 to 7. It was concluded that the structure will pass 74 percent of the Probable Maximum Flood without overtopping. The 100-year frequency flood will not overtop the dam.

E. Structure:

No design information for the 6 in. steel pipe dewatering structure was obtained.

2.2 CONSTRUCTION:

No construction inspection data have been obtained.

2.3 OPERATION:

The lake level is normally kept below the crest of the primary spillway by opening the 6 in. gate valve of the dewatering structure. During high flood events, flood flows will pass through the uncontrolled primary and emergency spillways. The owner reported that the lake is drawn down about 4 ft every fall and winter to control aquatic vegetation. In addition, the embankment face is mowed annually.

2.4 EVALUATION:

A. Availability:

No engineering data, seepage or stability analyses, or construction test data were available.

B. Adequacy:

The engineering data available were inadequate to make a detailed assessment of the design, construction, and operation of this structure. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

To our knowledge, no valid engineering data on the design or construction of the embankment are available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on August 24, 1979. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

Jack Healy - Hanson Engineers, Inc. (Geotechnical Engineer)
Gene Wertepny - Hanson Fngineers, Inc. (Hydraulic Engineer)
Dan Kerns - Hanson Engineers, Inc. (Geotechnical Engineer)
Steve Brady - Anderson Engineering, Inc. (Civil Engineer)
Tom Beckley - Anderson Engineering, Inc. (Civil Engineer)

B. Dam:

The dam appears to be generally in good condition. There is minor erosion at the north abutment contact. No sloughing or erosion has occurred on the upstream or downstream face of the dam. Shallow auger probes into the embankment indicate the dam to consist of a brownish red clay with some silt and rock fragments. Information from the owner indicates that borrow material for construction of the embankment was obtained from the hillside on the north and south valley walls upstream of the dam. No wave protection is provided for the upstream face of the dam.

No instrumentation (monuments, piezometers, etc.) was observed. A possible seepage area was noted at Station 2+80 on the downstream face of the dam. Some seepage was noted beyond the toe of the dam in the old stream channel. No significant flow was observed.

C. Appurtenant Structures:

C.1 Primary Spillway:

The grass-covered approach channel to the north spillway is clear (see Photo No. 7). No non-erodible control section is provided for the spillway. The outlet channel is clear for about 100 ft, then enters a wooded area. The spillway outlet channel cascades down exposed bedrock ledges before it enters the valley somewhat downstream of the toe of the embankment. Some seepage (probable spring) was noted at the base of the valley wall in the spillway outlet channel (see Photo No. 18). The flow from this area was negligible.

C.2 Emergency Spillway:

The emergency spillway at the south end of the dam is clear (see Photo No. 11). The spillway also functions as a drain for part of the hillside along the south abutment. The discharge channel is well away from the embankment.

C.3 Drawdown Pipe:

The 6 in. diameter steel drawdown pipe and valve appeared to be in good condition.

D. Reservoir:

The watershed is generally wooded, with no agricultural activity. The slopes adjacent to the lake are moderate, and no sloughing or serious erosion was noted.

E. Downstream Channel:

The discharge channel of the spillway and dewatering channel contains brush and debris.

3.2 EVALUATION:

There is no wave protection provided for the upstream face of the embankment. A non-erodible control section is not provided for the primary spillway; therefore, progressive erosion could lower the elevation of the spillway, and thus lower the normal pool elevation of the reservoir. The erosional areas at the north abutment-dam contact could worsen and adversely affect the stability of the dam. The possible seepage beyond the downstream toe of the dam and at Station 2+80 on the embankment face should be investigated by an engineer experienced in the design and construction of dams.

All of these deficiencies should be corrected under the direction of an engineer experienced in the design and construction of dams.

Because the valve of the lake drain is located on the downstream side of the dam, the full head of water impounded by the dam is acting entirely through the dam. The area around the lake drain outlet should be periodically inspected for seepage which might indicate a leak or rupture of the drain pipe and could eventually initiate a piping failure through the embankment.

Photographs of the dam, appurtenant structures, and the reservoir are presented in Appendix D.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

The primary and emergency spillways are uncontrolled. The lake level is controlled by the gated 6 in. steel outlet pipe which is opened when the level of the lake approaches the crest of the primary spillway.

4.2 MAINTENANCE OF DAM:

The lack of brush or tree growth indicates that the dam has been well maintained.

4.3 MAINTENANCE OF OPERATING FACILITIES:

The owner indicated that he draws down the lake about 4 ft below the crest of the primary spillway every fall to control weed growth and repair any bank erosion that may have occurred during the year. The drawdown pipe and valve appeared to be in good condition.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

The inspection team is unaware of any existing warning system for this dam.

4.5 EVALUATION:

The wet area (apparently seepage) at Station 2+80, erosion at the north abutment-dam contact, lack of erosion protection for the upstream face of the dam, and lack of a non-erodible control section for the primary spillway are serious deficiencies which should be corrected. However, these should only be accomplished under the direction of an experienced engineer to avoid creating an unsafe condition.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. & B. Design and Experience Data:

The hydraulic and hydrologic analyses were based on: (1) a field survey of spillway dimensions and embankment elevations; and (2) an estimate of the pool and drainage areas from the U.S.G.S. quad sheet. The owner indicated that the high water of record has been about 1 ft above the elevation of the primary spillway. The emergency spillway has not been used for lake overflow. Our hydrologic and hydraulic analyses using U.S. Army Corps of Engineers guidelines appear in Appendix C.

C. Visual Observations:

A non-erodible control section is not provided for the primary spillway. The spillway channels are well separated from the embankment, and spillway releases would not be expected to endanger the dam.

D. Overtopping Potential:

Based on the hydrologic and hydraulic analysis presented in Appendix C, the combined spillways will pass 74 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this structure (intermediate size with high downstream hazard potential) pass the PMF, without overtopping. The structure will pass a 100-year frequency flood without overtopping.

The routing of the PMF through the spillways and dam indicates that the dam will be overtopped by 0.76 ft at elevation 856.66. The duration of the overtopping will be 0.33 hours and the maximum outflow will be 6173 cfs. The maximum discharge capacity of the spillways is 3995 cfs. Overtopping of an earthen embankment can cause serious erosion and could possibly lead to failure of the structure. However, considering the relatively low height and duration of overtopping and the clayey nature of the embankment materials, the design flood would not be expected to cause considerable damage to the structure.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Sections 3.1B and 3.2.

B. Design and Construction Data:

No design and construction data for the foundation and embankment were available. Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

The post-construction changes include widening the crest of the embankment 4 ft in 1978.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is generally in very good condition. Several items were noted during the visual inspection which should be investigated further, corrected or controlled. These items are: (1) some minor erosion at the north abutment-dam contact; (2) lack of wave protection for the upstream face of the dam; (3) possible seepage areas beyond the toe of the dam in the old stream channel and at Station 2+80 on the embankment face; and (4) lack of a non-erodible control section for the primary spillway.

The dam will be overtopped by flows in excess of 74 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on the performance history as related by the owner, and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. If the deficiencies listed in paragraph A are not corrected, and if good maintenance is not provided, the embankment condition will deteriorate and possibly could become serious in the future. The item recommended in paragraph 7.2A should be pursued on a high priority basis.

D. Necessity for Phase II:

Based on the result of the Phase I inspection, no Phase II inspection is recommended.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

A. Alternatives:

(1) Spillway size and/or height of dam should be increased to pass the PMF. In either case, the spillway should be protected to prevent erosion.

B. O&M Procedures:

(1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the construction of dams.

(2) A non-erodible control section should be provided for the primary spillway so that progressive erosion of the spillway will not lower the normal pool of the reservoir.

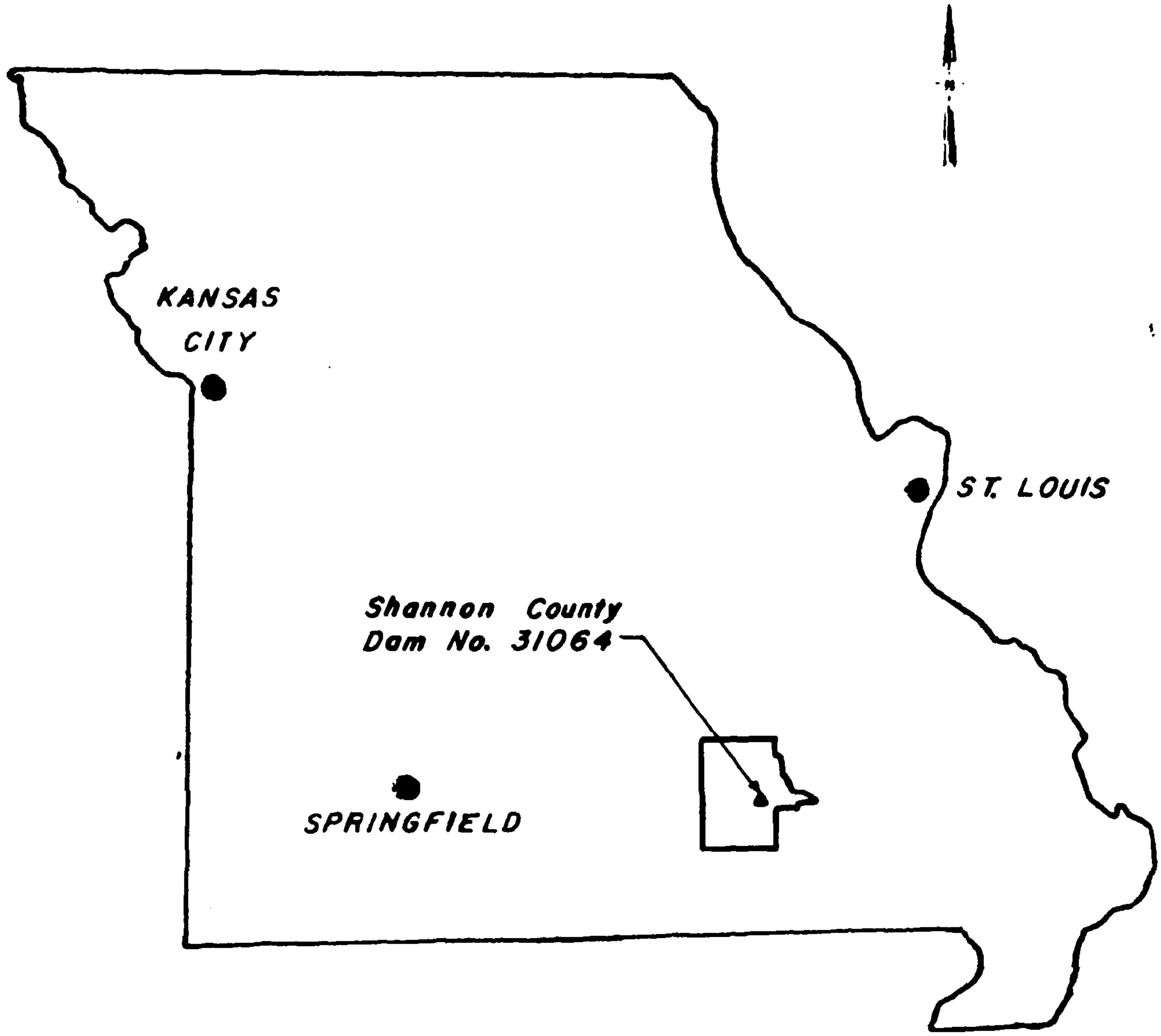
(3) The seepage beyond the downstream toe of the dam on the embankment face at station 2+80 and at the base of the primary spillway outlet should be investigated by an engineer experienced in the design and construction of dams. Remedial measures may be required. As a minimum, this seepage should be monitored to determine if there is any increase in quantities and whether soil particles are being carried with the water.

(4) Wave erosion protection should be provided for the upstream face of the embankment.

(5) The erosion at the abutment-dam contacts should be corrected and maintained.

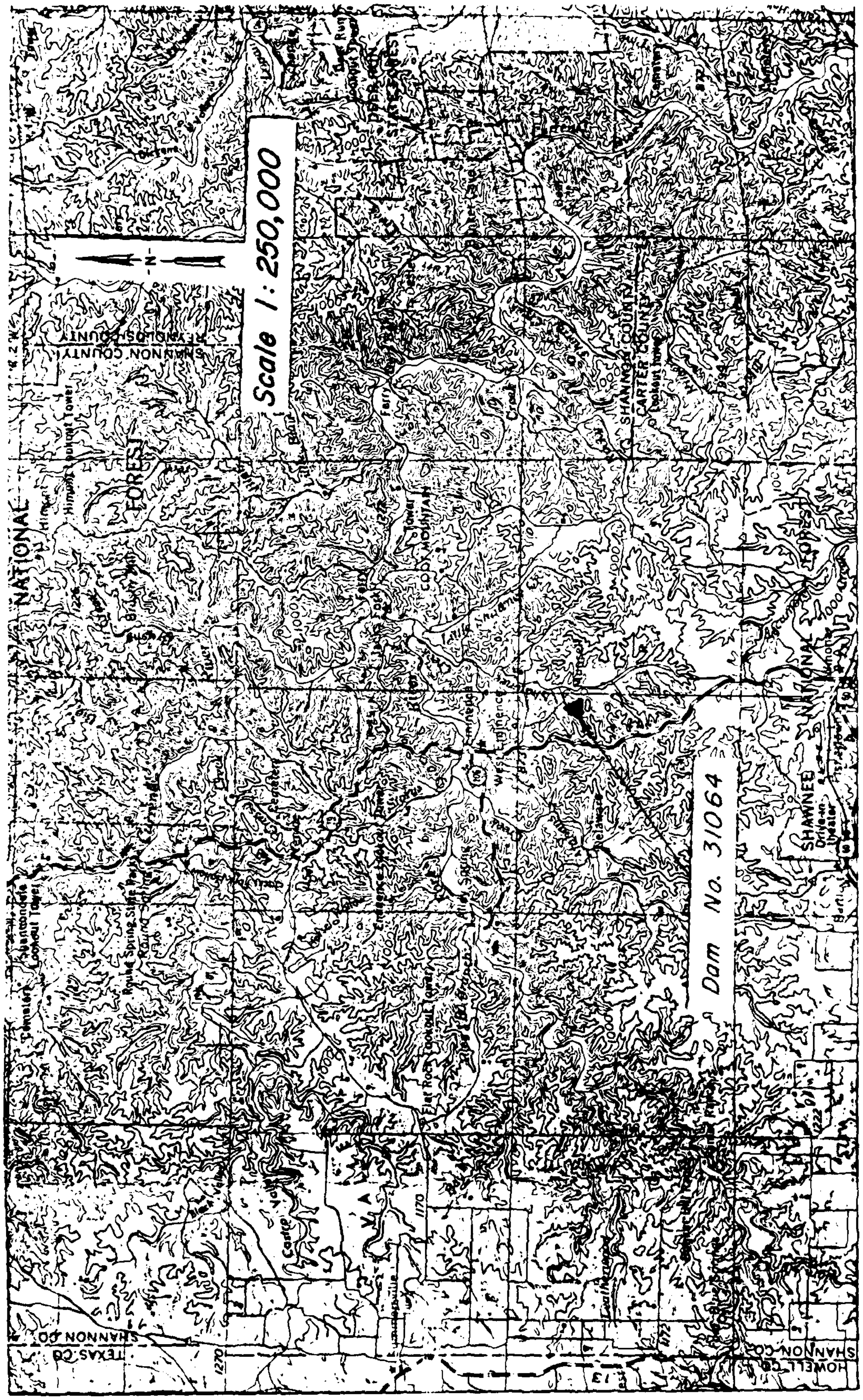
(6) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

APPENDIX A

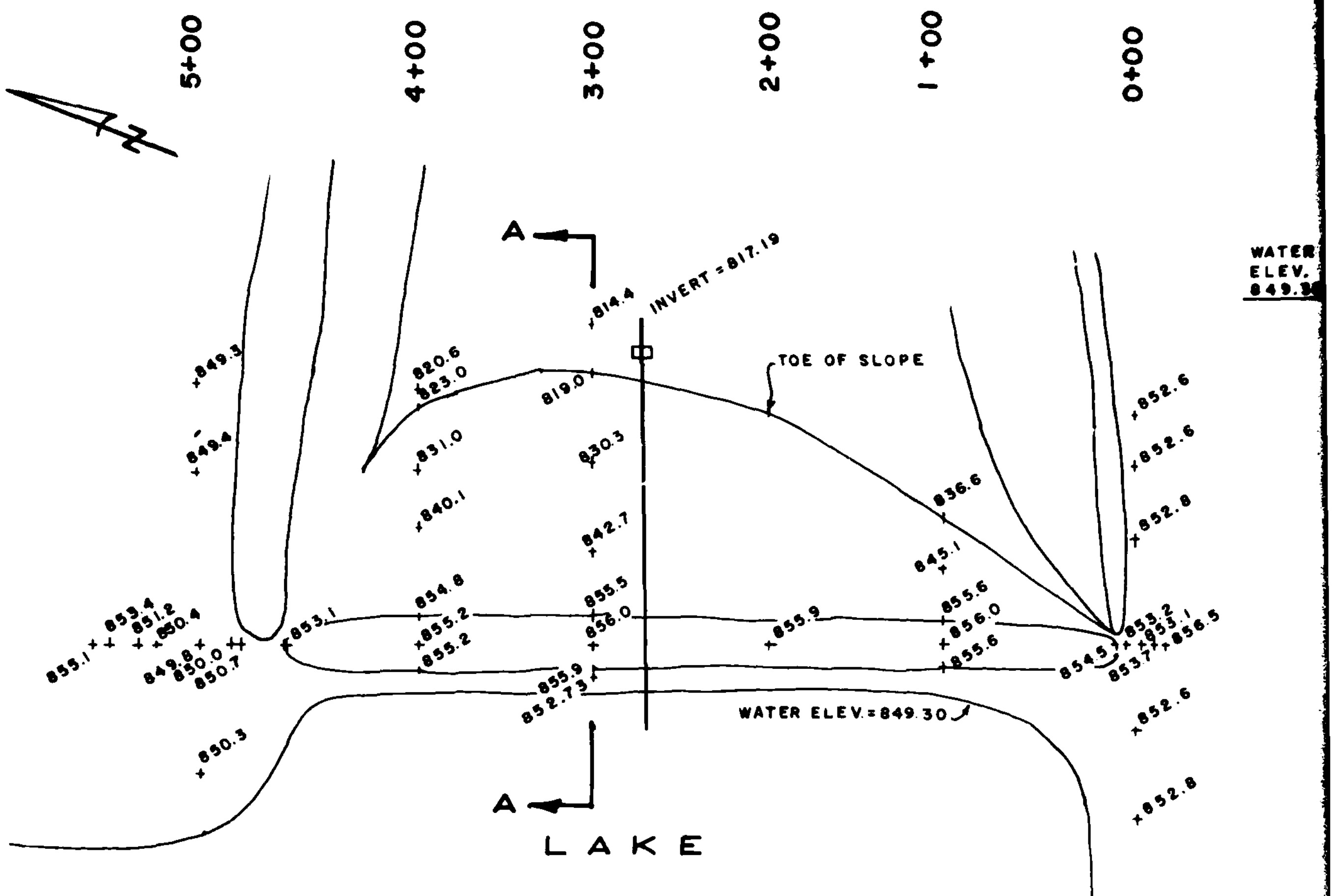


LOCATION MAP

SHEET 1 OF APPENDIX A

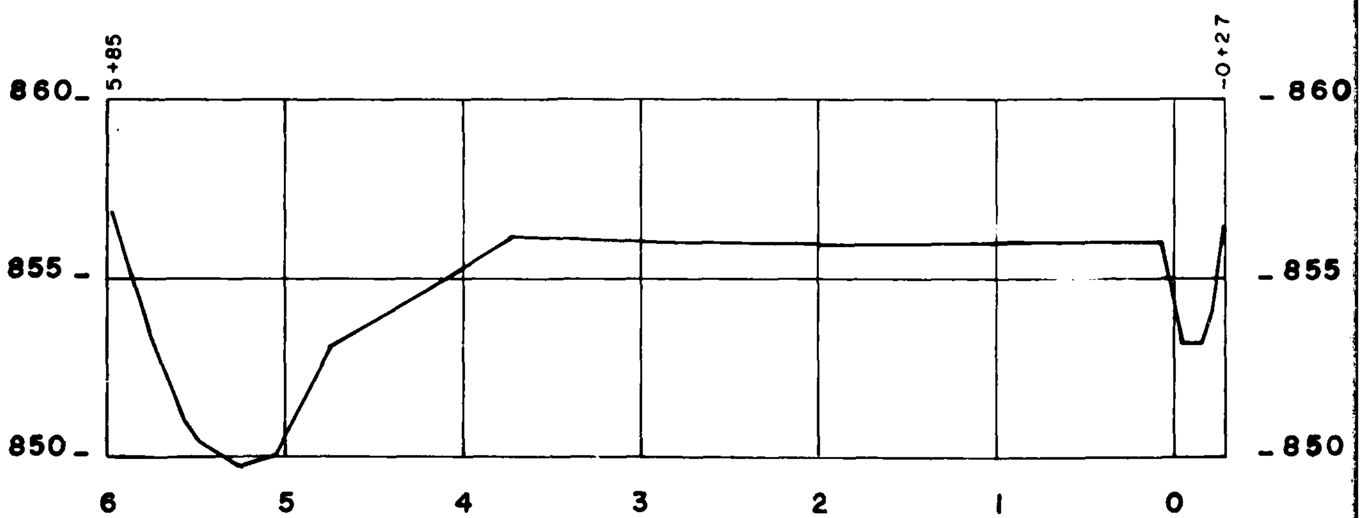


SITE VICINITY MAP



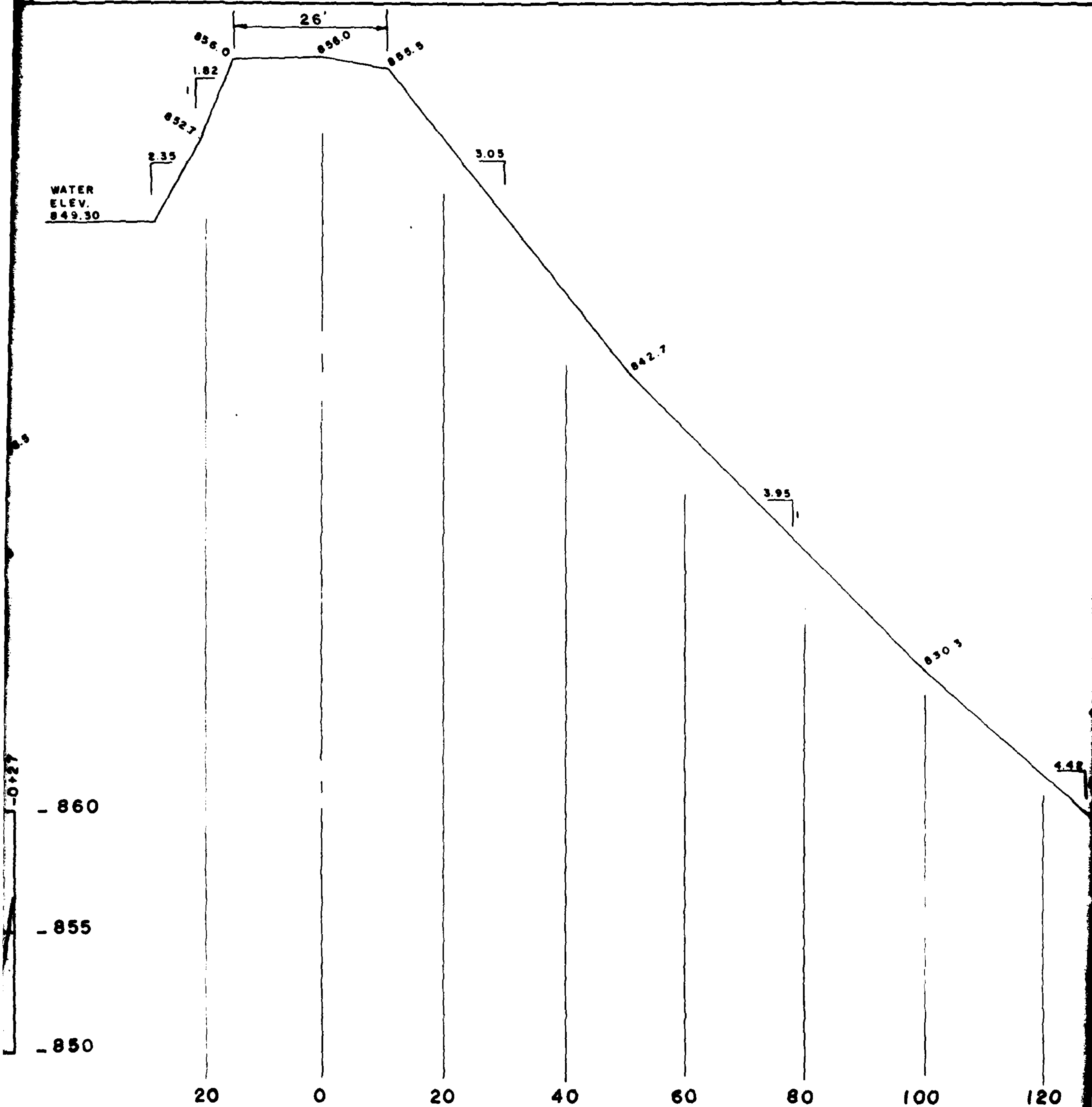
BENCHMARK:
TOP OF ROCK ON ℄
STA 5+65
ELEV. = 852.7 M S L

PLAN VIEW
SCALE · 1" = 100'

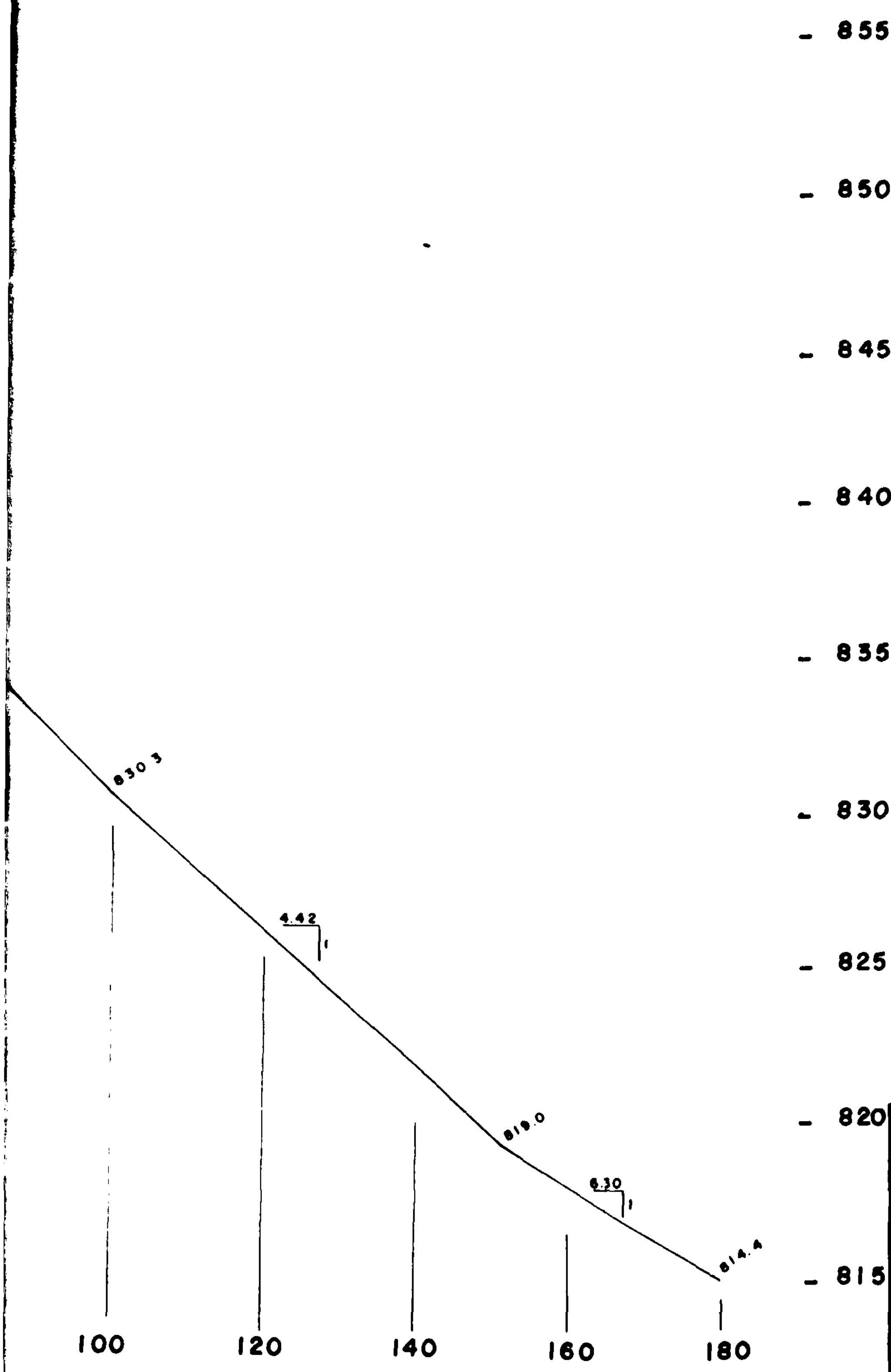


PROFILE

/



SECTION A-A STA 3+00



Sheet 3 of Appendix A

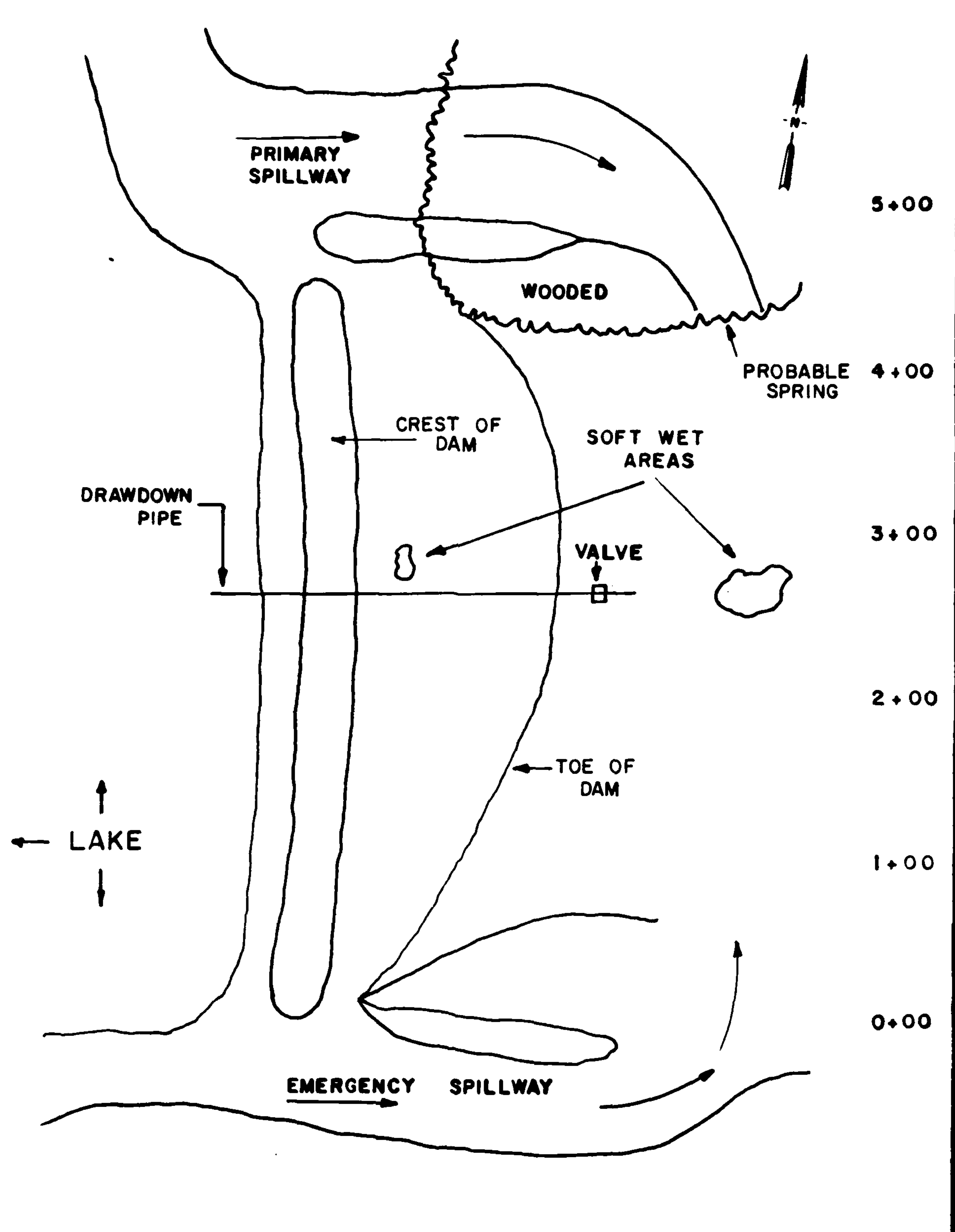
ANDERSON ENGINEERING, INC.
730 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

DEEL LAKE DAM

MO. No. 31064

PLAN & PROFILE

SHANNON COUNTY, MO.



PLAN SKETCH

HANSON ENGINEERS

SPRINGFIELD ILL. PEORIA ILL.

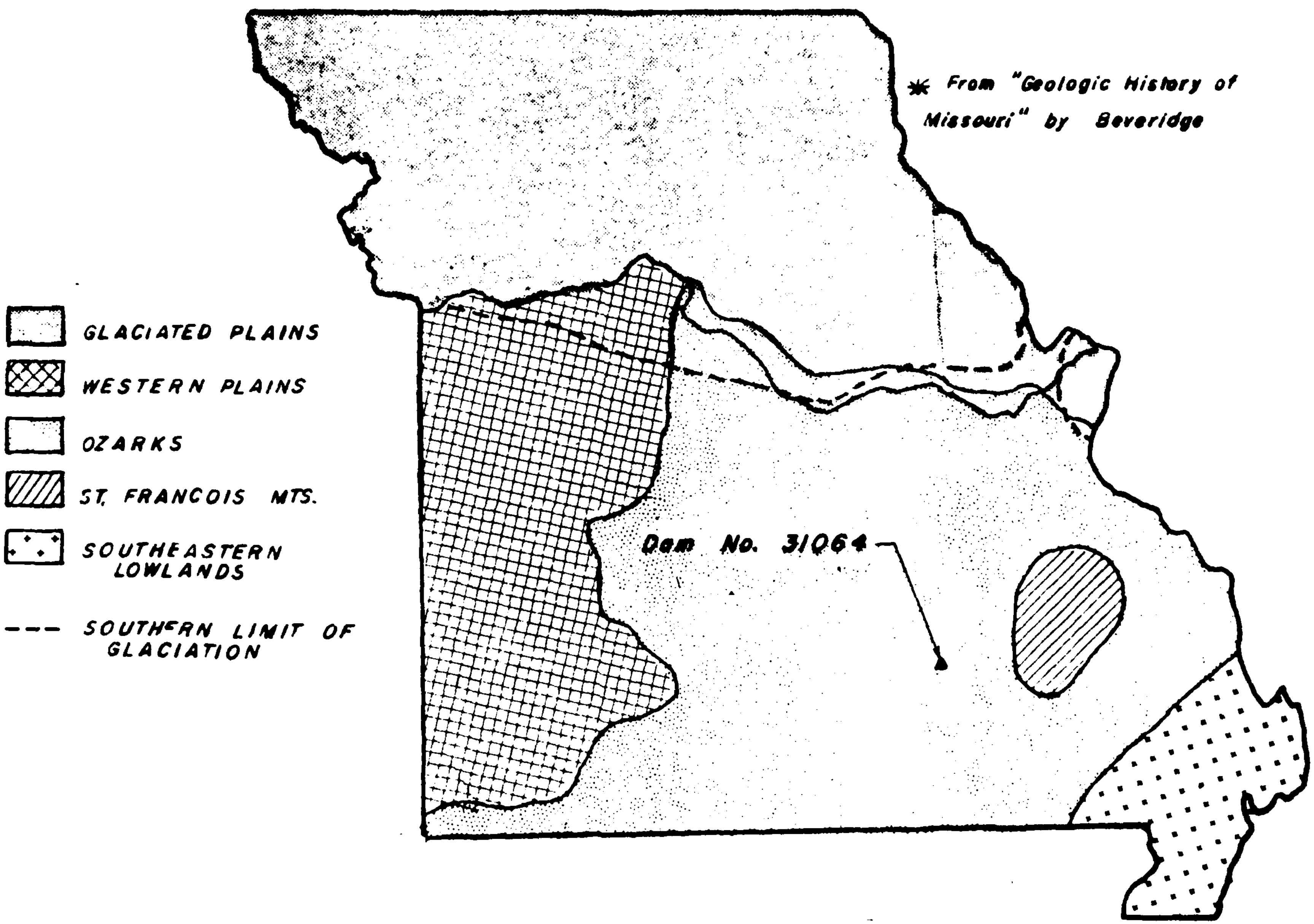
DEEL LAKE DAM

MO. I.D. NO. 31064

SHEET 4 APPENDIX A

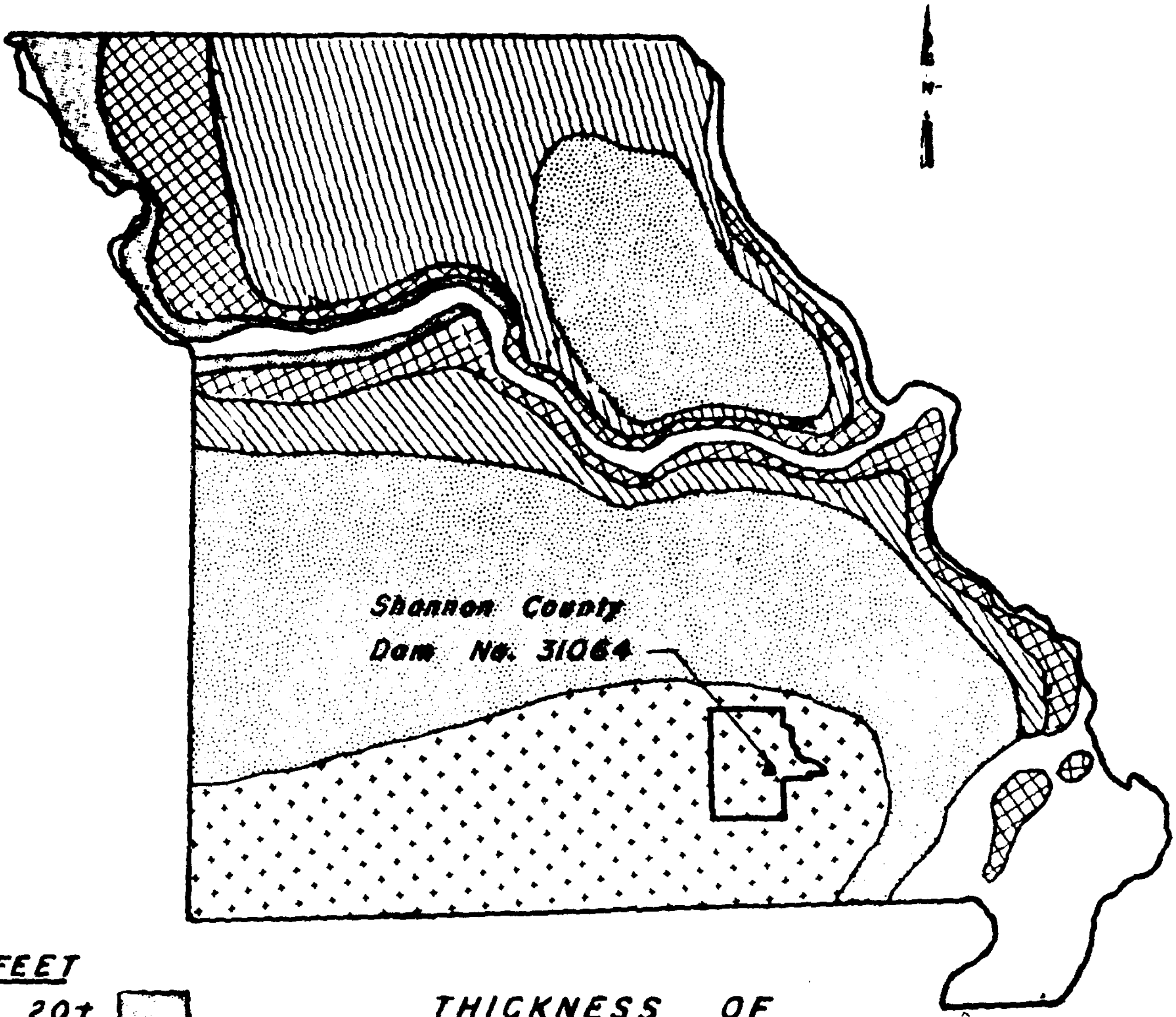
APPENDIX B

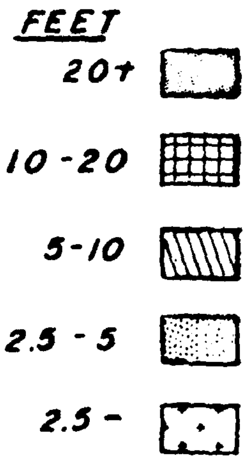
MAJOR GEOLOGIC REGIONS OF MISSOURI



SHEET 1 OF APPENDIX B

* From "Soils of Missouri"





THICKNESS OF LOESSIAL DEPOSITS

SHEET 2 OF APPENDIX B

E-

ENGINEERING GEOLOGIC REPORT OF THE DEEL LAKE SITES
SHANNON COUNTY

LOCATION: Lake Site No. 1 - Just downstream of the barn in Millman Hollow in the W½ NE¼ SE¼ NW¼, sec. 13, T. 28 N., R. 4 W., Winona Quadrangle.

Lake Site No. 2 - A larger lake 2,000 feet downstream of No. 1, with the dam site in the NW¼ SE¼ NE¼, sec. 13, T. 28 N., R. 4 W., Winona Quadrangle

Lake Site No. 3 - In Black Valley with the dam site in the NE¼ NW¼ NE¼, sec. 18, T. 28 N., R. 3 W., Winona Quadrangle.

SUITABILITY:

All three lake sites are in the Eminence Formation which is very badly jointed and solutioned. Lake site No. 1 appears to be feasible. Lake site No. 2, just downstream, appears feasible, but needs some subsurface drilling information. Site No. 3 appears feasible from the geologic standpoint.

GEOLOGY:

Millman Hollow, a tributary of Shawnee Creek, is in the Eminence Formation. The Eminence in this area is very badly weathered, pinnacled and much solution work has taken place on both the vertical joints and the horizontal bedding planes. Numerous springs attest to the permeability of the bedrock both upstream and downstream of the proposed dam site. Most of the small springs eminate from the bedrock at elevations above the water level of the proposed lake, except Millman Spring downstream on the topographic nose. Millman Spring was dry on the date of this investigation. It is assumed that it drains the ridge areas on the south side of Millman Hollow. Bedrock outcrops both upstream and downstream of the proposed dam site, but a thick clay layer is present on the right, or south, abutment within the lake basin. The stream is carrying a small amount of water and is reported to be perennial. This indicates that the bedrock in the basin bottom does not have excess permeability. The water in Millman Hollow disappears into stream gravels at the junction of Abe Hollow to the south.

Four test pits were dug on the valley bottom and south valley slope to determine the quality and quantity of material overlying the bedrock on the center line of the proposed dam.

Test pit No. 1 was on the floodplain near the junction of the valley wall and valley bottom near the left or north abutment. Although bedrock outcrops on the north valley wall, the test pit penetrated 3 feet of gravel material overlying 4 feet of gravelly clay and bottoming out in 3 feet of dolomitic, sandy clay material. Bedrock was intercepted at about 10 feet. A very small amount of water could be seen seeping into the bottom of the test pit.

Test pit No. 2 was on the left side of the stream on the floodplain. The test pit went through 2 feet of gravel and 6 feet of clayey gravel, bottoming out in bedrock at 8 feet. Test pit No. 2 was dry.

Test pit No. 3 was in the floodplain just to the right (south) of the stream bed. Test pit 3 penetrated 2 feet of gravel on the surface, 2 feet of good quality clay material with a small amount of gravel and then 3 feet of gravelly clay bottoming out in rock at 8 feet. There was a very small amount of water in test pit No. 3.

Test pit No. 4 was excavated about half-way between the valley bottom and the proposed water line on the right abutment. This test pit penetrated 12 1/2 feet of yellow-tan plastic clay with a very small amount of chert. No water was seen in test pit 4.

The presence of the thick quantity of residual clay material that appears to be relatively impermeable on the right valley slope and the thick quantity of material in the basin bottom, indicates that this lake site has the potential for a water impoundment structure.

The drainage area for lake site No. 1 encompasses about 370 surface acres. Thirty feet of water projected on a 7.5-minute map, would cover from 16 to 18 surface acres. This lake area is an estimate and should be surveyed if this information is necessary.

RECOMMENDATIONS:

Site No. 1

1. It is recommended that a core be placed across the entire valley bottom and up the valley walls on both sides of the valley. Although the valley bottom is covered by from 6 to 8 feet of relatively watertight clayey gravel, it is recommended that the core be extended to and into rock as far as possible across the valley bottom. The three test pits on the floodplain bottomed in rock at approximately the same level, but it is anticipated that the bedrock is very pinnacled and/or uneven, and open channels could be present at the contact between the gravel material and the weathered bedrock. An attempt should be made to even out the bedrock, all pinnacles and loose and weathered rock removed by ripping or other means, and clay for the core compacted on firm, fresh bedrock, if at all possible.

When the core comes out of the valley bottom on the right or south abutment, it should be carried in bedrock until the residual material on the south slope becomes 6 or 8 feet thick. It is not thought necessary to core to bedrock all the way up the right abutment. Where the residual material is thick, approximately 6 feet, penetration of the core is thought adequate, but at the contact between the slope and the valley floor the core should be excavated as far into the weathered bedrock as practical.

The left abutment has exposed bedrock from the valley bottom to the top of the proposed water line. Large, loose blocks of Eminence dolomite have slumped on the slope and should be removed with a bulldozer or other means. When the large blocks are pushed off the slope, there may be open horizontal bedding planes that would carry considerable quantities of water in a lateral direction. If these openings exist, ripping or other means should be used to breakoff the rock and clay for the core compacted on firm, fresh bedrock. If the weathered bedrock cannot be broken or otherwise removed, it is recommended that the core area on the left abutment be widened out considerably by removal of a wide swath of the large slumped rock blocks.

2. It is recommended that the left abutment be placed on the downstream side

of the topographic nose in that area. The soil cover and bulk of the topographic nose will afford considerable protection against lateral seepage around the left abutment.

3. It is recommended that no borrow material be removed from the valley bottom or valley walls below the proposed water line, except perhaps at or just below the shore line to improve shore line conditions. Twelve and one-half feet of residual material was penetrated on the right abutment, but the Eminence Formation weathers in a pinnacle affect and the thickness of the residual material may vary considerably in short distances upstream. The numerous springs downstream of the right abutment, reveal the extremely high permeability of the bedrock in that area. The thick residual cover is necessary to prevent rapid lateral water loss into the bedrock. At least 6 or more feet of residual material should be left on the right abutment.

An area on the west side of the first gully upstream, has from 4 to 6 feet of good quality borrow material suitable for construction of the earthen dam.

If any unusual geologic features are encountered during excavation, this office would be happy to evaluate them.

Lake Site No. 2

Lake site No. 2 is just downstream of lake site No. 1 and would impound water in both Millman and Abe Hollows. Forty feet of water at the dam (see accompanying map) would create a lake of approximately 67 1/2 surface acres. The drainage area for the two tributary valleys would be approximately 950 acres, and should be sufficient to sustain a stable water line in a lake of this size, provided that no adverse leakage conditions are encountered. The water from both Millman and Abe Hollows is lost in the shallow alluvium approximately at the proposed dam site. It is thought that this water loss is shallow and could be intercepted with a core trench in the alluvial material. The left abutment at lake site No. 2 would be in residual material with ample soil cover over the bedrock. The right abutment, somewhat more steep, has a very shallow soil cover and water loss laterally into the bedrock is a distinct possibility.

If construction of lake site No. 2 is contemplated, it is recommended that a backhoe be used to excavate 6 to 8 holes on the floodplain on the center line of the dam to determine the depth to bedrock and if large quantities of water can be found above the bedrock. If very little water is found in the alluvial gravels, water is disappearing into the bedrock and drilling the center line on at least 100 foot centers would be necessary. The drilling should penetrate at least 20 feet of bedrock and pressure tested to determine the permeability and depth of weathered rock. It is recommended that at least one or more drill holes be drilled on the right abutment from the elevation of the proposed water line to a depth of 10 or 20 feet below floodplain elevation. This information would be necessary to determine the permeability of the abutment and the depth that it would be necessary to excavate into the abutment with a core trench to cutoff lateral permeability. If coring depth is excessive, grouting may be necessary.

Lake Site No. 3

Lake No. 3, in the NE¼, sec. 18, has a reasonably thick cover of residual soil on both abutments and the valley bottom. Eminence bedrock can be seen outcropping in the left fork upstream of the dam site. Small seeps and springs, thought to be coming from the east along the contact between shallow surface clays, can be seen just upstream of the proposed dam. Twenty feet of water in this area would create a lake of approximately 3 acres. Forty feet of water would create a lake of about 11 surface acres. The drainage area encompasses about 110 acres and would be sufficient for lake development of this size.

RECOMMENDATIONS:

1. Depending on thickness of residual and alluvial material, the core in the abutments should bottom out in at least 3 to 4 feet of good quality clayey material. In the valley bottom the core should bottom out at least 2 to 3 feet below the last gravel or water bearing zone.

2. Other recommendations pertaining to lake site No. 1 would pertain to lake site No. 3.

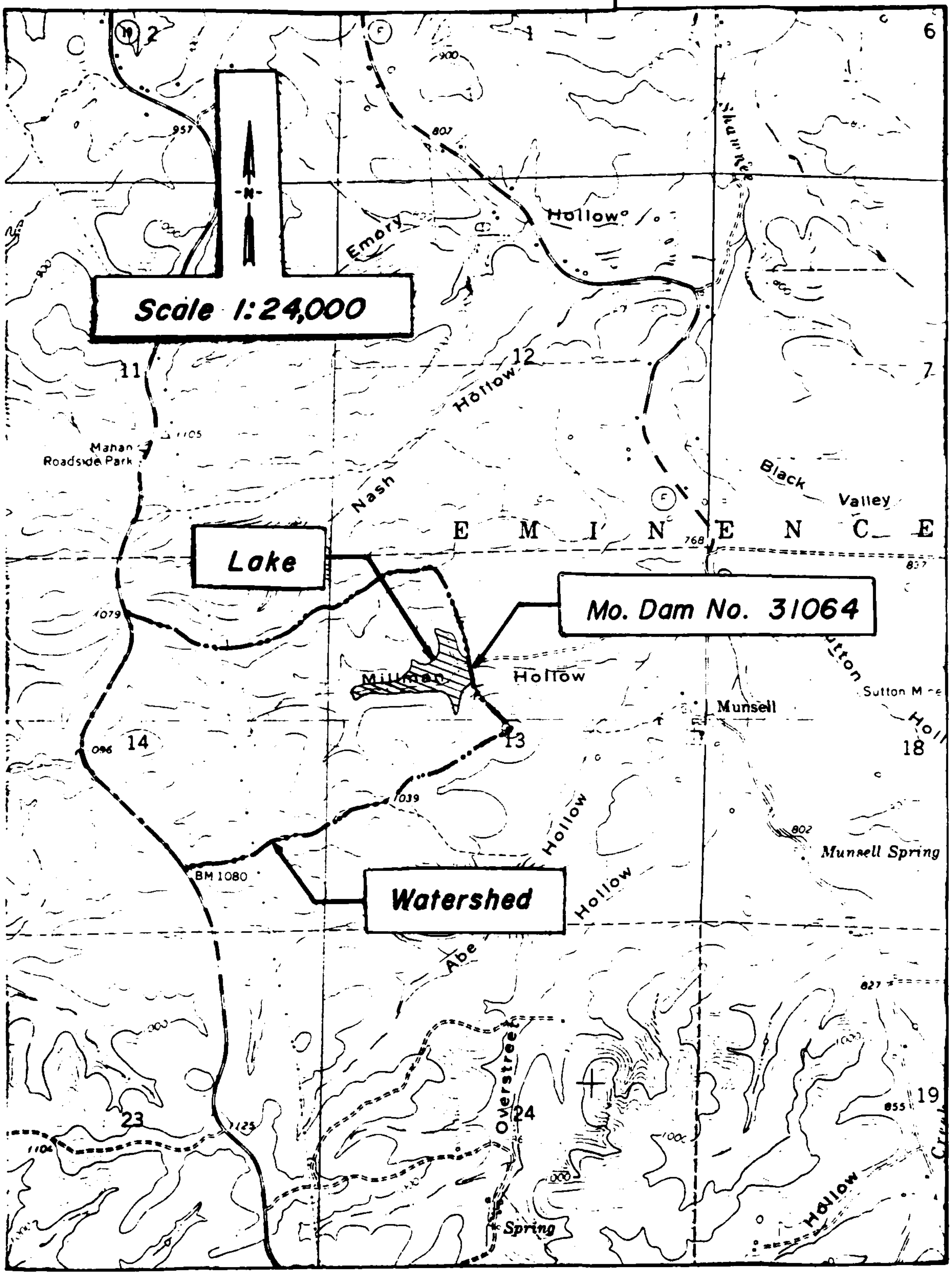
SUMMARY:

Lake site No. 3 appears to have a high potential for water holding capability.

Thomas J. Dean
Geologist
Engineering Geology Section
Missouri Geological Survey
November 16, 1971

APPENDIX C

From Winona 7.5' Quad



LAKE AND WATERSHED MAP

Sheet 1 Appendix C

HYDRAULIC AND HYDROLOGIC DATA

Design Data: From Field Measurements and Computations

Experience Data: No records are available. The owner of the dam annually draws down the lake about 4 ft in the fall to control weed growth and bank erosion. Maximum high water has been about a foot above the primary spillway. The emergency spillway has not been used. The dam has never been overtopped.

Visual Inspection: At the time of the inspection, the pool level was approximately 0.50 ft below normal pool.

Overtopping Potential: Flood routings were performed to determine the overtopping potential. The watershed and the reservoir surface areas were obtained by planimeter from the U.S.G.S. Winona, Missouri 7.5 minute quadrangle map. The storage volume was developed from these data. A 5 minute interval unit graph was developed for this watershed, which resulted in a peak inflow of 1480 c.f.s. and a time to peak of 11 minutes. Application of the probable maximum precipitation minus losses results in a flood hydrograph peak inflow of 7581 c.f.s. Rainfall distribution for the 24 hour storm was according to EM 1110-2-1411.

Based on our analyses, the combined spillways will pass 74 percent of the Probable Maximum Flood (PMF). The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that the structure (intermediate size with high downstream hazard potential) pass the PMF, without overtopping. Considering that the height of the dam is 41 ft and that the volume of water impounded is 296 ac-ft, the PMF has been determined to be the appropriate spillway design flood.

The routing of the PMF through the spillway and dam indicates that the dam will be overtopped by 0.76 ft at elevation 856.66. The duration of the overtopping will be 0.33 hours, and the maximum outflow will be 6173 c.f.s. The maximum discharge capacity of the combined spillways is 3995 c.f.s. Analysis of the data indicates that the 100-year frequency flood will not overtop the dam. The computer input, output and hydrograph for the PMF are presented on Sheets 5, 6 and 7 of Appendix C.

OVERTOPPING ANALYSIS FOR DEEL LAKE DAM

INPUT PARAMETERS

1. Unit Hydrograph - SCS Dimensionless - Flood Hydrograph Package (HEC-1); Dam Safety Version Was Used.
   Hydraulic Inputs Are As Follows:

   a. Twenty-four Hour Rainfall of 27 Inches For 200 Square Miles - All Season Envelope

   b. Drainage Area = 350 Acres; = 0.55 Sq. Miles

   c. Travel Time of Runoff 0.23 Hrs.; Lag Time 0.14 Hrs.

   d. Soil Conservation Service Soil Group B

   e. Soil Conservation Service Runoff Curve No. 78 (AMC III)

   f. Proportion of Drainage Basin Impervious 0.06

2. Spillways

   a. Primary Spillway: Trapezoidal cut on natural ground;
      Crest length = 30 ft, side slopes = vary; C = varies

   b. Emergency Spillway : Trapezoidal cut on natural ground
      Length 9 Ft.; Side Slopes vary ; C = varies

   c. Dam Overflow
      Length 365 Ft.; Crest El. 855.9 ; C = 3.0

3. Spillway and Dam Rating:

   Curve Prepared by Hanson Engineers. Data Provided To Computer on Y4 and Y5 Cards. (See Sheet 5, Appendix C
   Formula Used: Spillways: $\frac{Q^2}{g} = \frac{A^3}{T}$

   Dam: $Q = CLH^{1.5}$

Note: Time of Concentration From Equation $Tc = \left(\frac{11.9\ L^3}{H}\right)^{.385}$
California Culvert Practice, California Highways and Public Works, Sept. 1942.

SUMMARY OF DAM SAFETY ANALYSIS

1. Unit Hydrograph

   a. Peak - 1480 c.f.s.

   b. Time to Peak 11 Min.

2. Flood Routings Were Computed by the Modified Puls Method

   a. Peak Inflow

      50% PMF 3790 c.f.s.; 100% PMF 7581 c.f.s.

   b. Peak Elevation

      50% PMF 854.72 100% PMF 856.66

   c. Portion of PMF That Will Reach Top of Dam

      74 %; Top of Dam Elev. 855.9 Ft.

3. Computer Input and Output Data are shown on Sheets 5 and 6 of this Appendix.

```
A       OVERTOPPING ANALYSIS FOR DEEL LAKE DAM ( # 12 )
A       STATE ID NO. 31064  CO. NO. 203  CO. NAME SHANNON
A       HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 79511
B    300               5
B1     5
J      1       7       1
J1   .15     .20     .30     .40     .50     .75     1.0
K      0       1                             3       1
K1      INFLOW HYDROGRAPH COMPUTATION **
M      1       2    0.55            0.55     1                       1
P      0    27.0     102     120     130
T                                                   -1     -78             0.06
W2  0.23    0.14
X      0     -.1       2
K      1       2                       0       4       1
K1      RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE **
Y                                1       1
Y1     1                                             187      -1
Y4 849.8   851.0   852.0   853.1   854.0   855.0   855.9   857.0   857.4   859.0
Y5     0     150     460    1020    1715    2750    3995    6075    7110   11400
$A     0      16    20.2      23
$E 815.0   849.8   855.9   860.0
$$ 849.8
$D 855.9     3.0     1.5     365
K     99
```

P.M.F. Input Data
Sheet 5, Appendix C

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

				RATIOS APPLIED TO FLOWS						
OPERATION	STATION	AREA	PLAN	RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7
				0.15	0.20	0.30	0.40	0.50	0.75	1.00
HYDROGRAPH AT	1	0.55	1	1137.	1516.	2274.	3032.	3790.	5685.	7581.
	(	1.42)	(	32.20)(	42.93)(	64.40)(	85.86)(	107.33)(	160.99)(	214.66)(
ROUTED TO	2	0.55	1	533.	776.	1286.	1859.	2465.	4064.	6173.
	(	1.42)	(	15.10)(	21.97)(	36.41)(	52.64)(	69.81)(	115.08)(	174.79)(

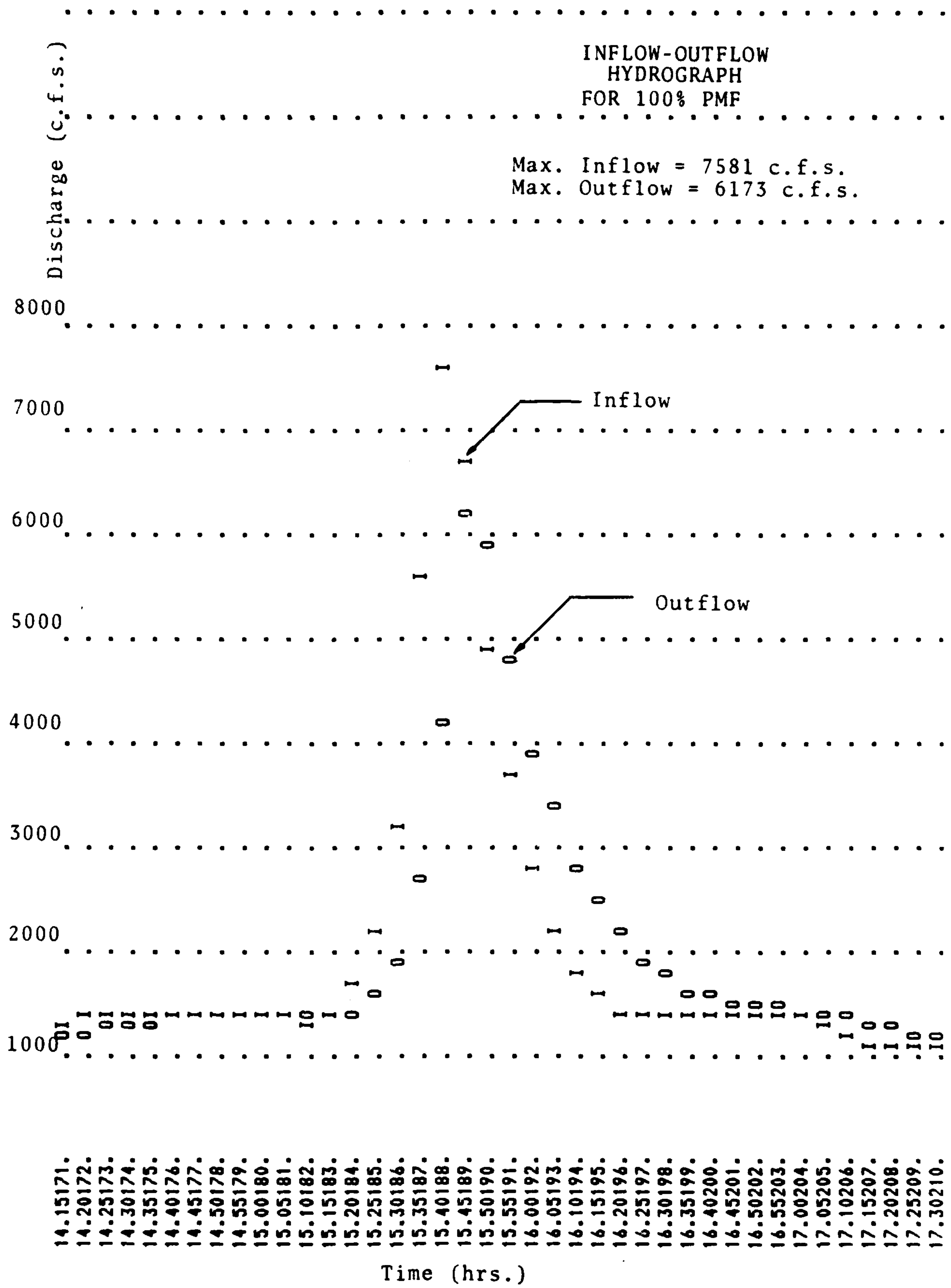
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	849.88	849.80	855.90
STORAGE	187.	186.	296.
OUTFLOW	10.	0.	3995.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.15	852.14	0.00	225.	533.	0.00	15.92	0.00
0.20	852.62	0.00	233.	776.	0.00	15.92	0.00
0.30	853.44	0.00	248.	1286.	0.00	15.92	0.00
0.40	854.14	0.00	261.	1859.	0.00	15.83	0.00
0.50	854.72	0.00	273.	2465.	0.00	15.83	0.00
0.75	855.93	0.03	296.	4064.	0.08	15.83	0.00
1.00	856.66	0.76	311.	6173.	0.33	15.75	0.00

P.M.F. Output Data
Sheet 6, Appendix C

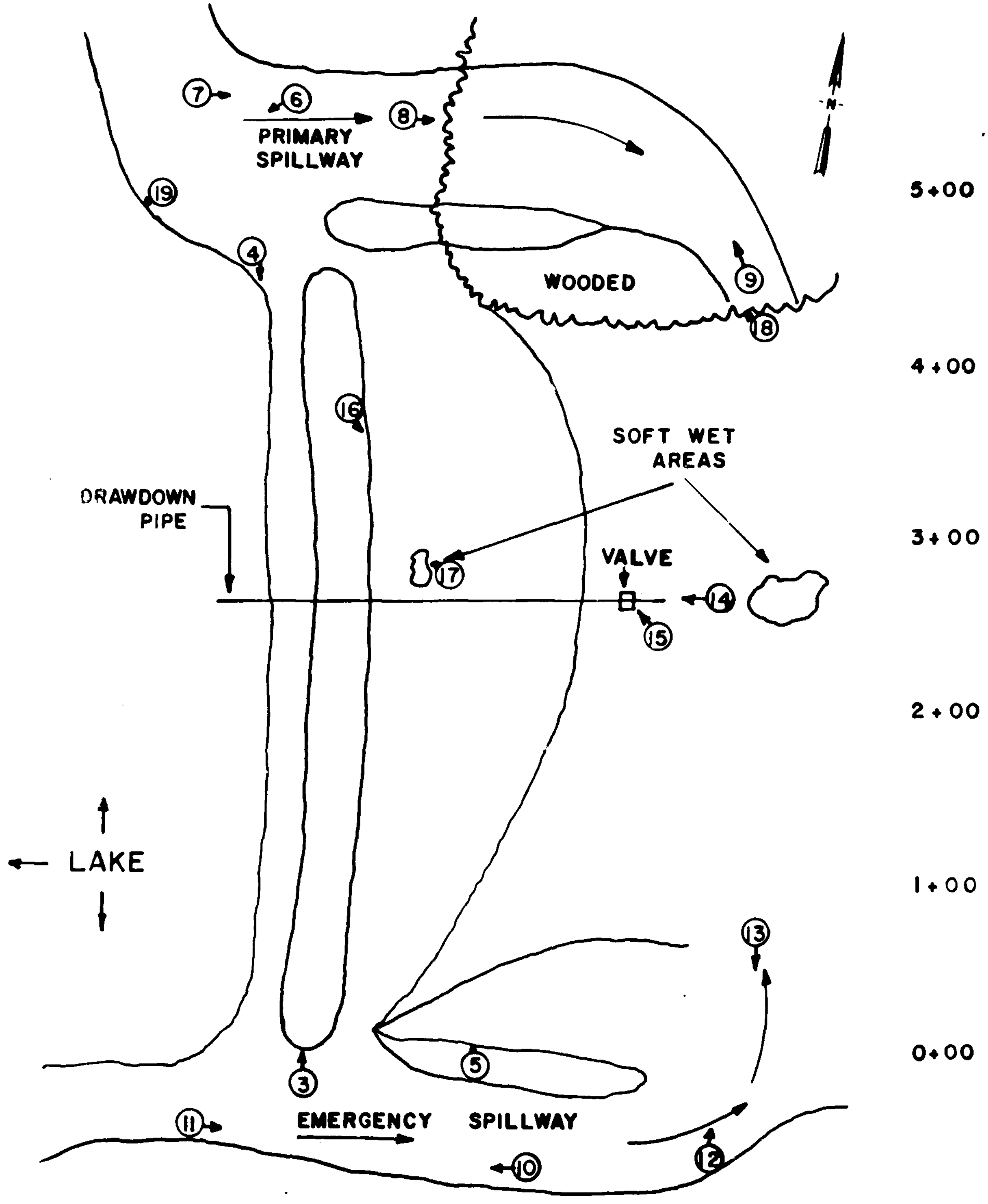


Sheet 7, Appendix C

APPENDIX D

INDEX TO PHOTOGRAPHS

Photo No.	Description
1	Aerial - Lake and Dam, Looking East
2	Aerial - Lake and Dam, Looking West
3	Crest of Dam, Looking North
4	Upstream Face of Dam, Looking South
5	Downstream Face of Dam, Looking North
6	Primary Spillway, Looking Upstream
7	Primary Spillway, Looking Downstream
8	Primary Spillway Discharge Channel, Looking Downstream
9	Primary Spillway Discharge Channel, Looking Upstream
10	Emergency Spillway, Looking Upstream
11	Emergency Spillway, Looking Downstream
12	Emergency Spillway Discharge Channel, Looking Downstream
13	Emergency Spillway Discharge Channel, Looking Upstream
14	Drawdown Pipe Outlet and Valve Enclosure
15	Drawdown Pipe Valve
16	View of Downstream Channel
17	Soft, Wet Area at Station 2+80
18	Seepage (Probable Spring) at Primary Spillway Outlet
19	View of Lake and Watershed



PLAN SKETCH

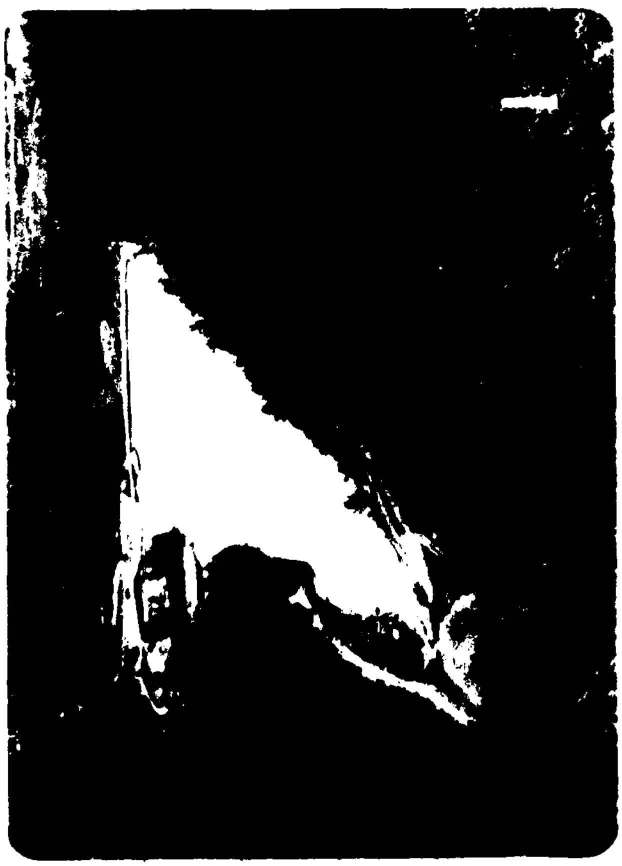
HANSON ENGINEERS INCORPORATED

SPRINGFIELD ILL. PEORIA ILL.

DEEL LAKE DAM

MO. I.D. NO. 31064

SHEET 2 APPENDIX D




5

6


10


12


14


15


61

N
N
30 EV

SUBJECT
LOCATION
OCCASION
FEBRUARY 1980 EV

SUBJECT
LOCATION
OCCASION
FEBRUARY 1980 EV

SUB
LOCA
OCCA
FEBRUARY

SUBJECT
LOCATION
OCCASION
FEBRUARY 1980 EV

SUBJEC
LOCATION
OCCASION
FEBRUARY 1980


FILME