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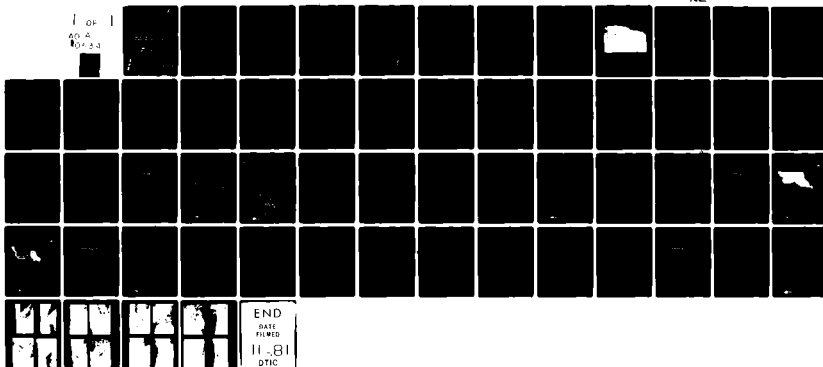
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OSAGE-GASCONADE RIVER BASIN

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TREELINE LAKE DAM

CAMDEN COUNTY, MISSOURI

MO 31606

**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

JULY, 1980

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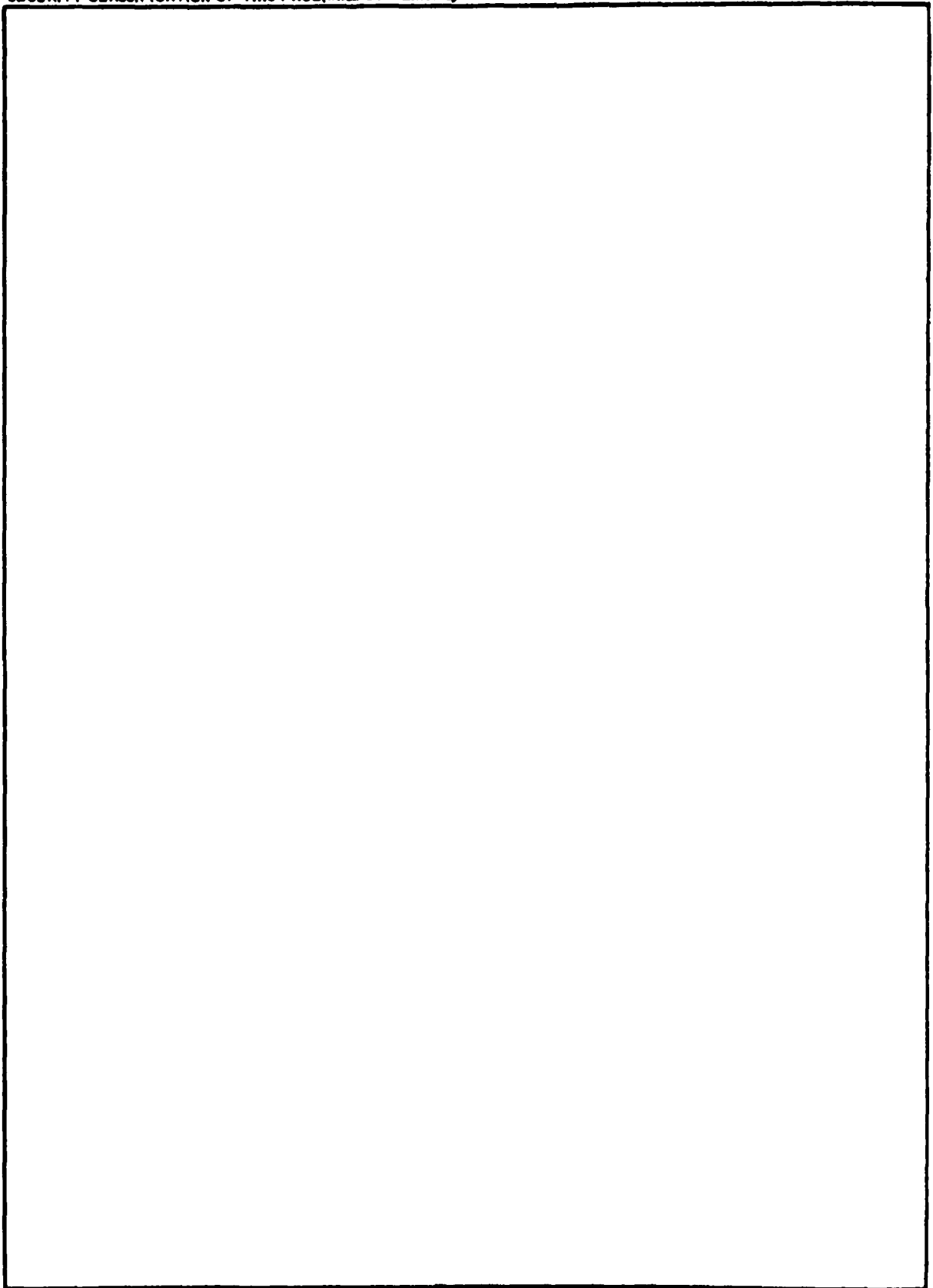
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This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards 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: Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Treeline Lake Dam (MO 31606).

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

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

- a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.
- b. Overtopping of the dam could result in failure of the dam.
- c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY:

Chief, Engineering Division

2 SEP 1980

Date

2 SEP 1980

APPROVED BY:

Colonel, CE, District Engineer

Date

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OSAGE-GASCONADE RIVER BASIN

TREELINE LAKE DAM

CAMDEN COUNTY, MISSOURI

MISSOURI INVENTORY NO. 31606

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

JULY 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
SUMMARY

Name of Dam:	Treeline Lake Dam
State Located:	Missouri
County Located:	Camden
Stream:	Unnamed Tributary of Osage River
Date of Inspection:	April 28, 1980

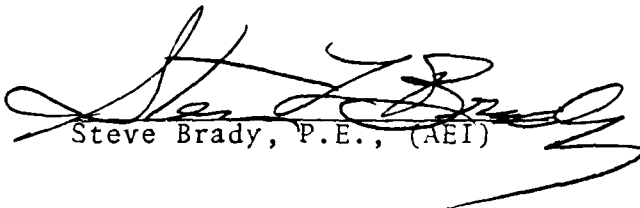
Treeline Lake Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based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

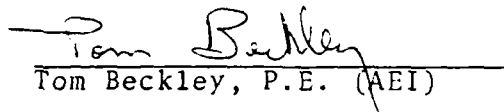
The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis 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 1 mile downstream of the dam. Located within this zone are approximately 24 dwellings along the Lake of the Ozarks shoreline. The existence of these dwellings was verified during the field inspection and at the time the aerial photographs were taken. The dam is in the intermediate size classification, since it is greater than 40 ft high but less than 100 ft high.

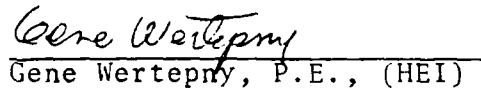
Our inspection and evaluation indicates that the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will pass 45 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood (PMF) is defined as the 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 1 percent probability flood will not overtop the dam. The 1 percent probability flood is one that has a 1 percent chance of being exceeded in any given year.

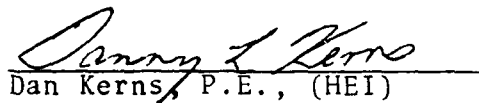
The dam appears to be in good condition. Deficiencies visually observed by the inspection team were: (1) high weed growth on both embankment faces; (2) several minor erosion channels and evidence of vehicular traffic on the downstream embankment face; (3) seepage and erosion at the downstream right abutment-dam contact; (4) wet, marshy area at and beyond the downstream embankment toe; (5) lack of a non-erodible spillway control section; and (6) lack of wave protection for the upstream embankment face. Another deficiency was the lack of seepage and stability analysis records.

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


Steve Brady, P.E., (AEI)


Tom Beckley, P.E. (AEI)


Gene Wertepny, P.E., (HEI)


Dan Kerns, P.E., (HEI)



AERIAL VIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
TREELINE LAKE DAM - ID No. 31606

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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 Treeline Lake Dam in Camden 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:

Treeline Lake Dam is an earth fill structure approximately 41 ft high and 740 ft long at the crest. In this report, right and left orientation is based on looking in the downstream direction. The appurtenant works consist of a trapezoidal cut earth spillway located at the left abutment. Sheet 3 of Appendix A shows a plan profile and typical section of the embankment.

B. Location:

The dam is located in the northeastern part of Camden County, Missouri on an unnamed tributary of the Osage River. The dam and lake are within the Lake Ozark, Missouri 7.5 minute quadrangle sheet (Section 30, T40N, R16W - latitude 38° 11.6'; longitude 92° 44.1'). 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 681 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 one mile downstream of the dam. Located within this zone are about 24 dwellings on the shore of Lake of the Ozarks.

E. Ownership:

The dam is owned by Four Seasons Lake Sites. The owner's address is: Rt. 2, P.O. Box 264M, Lake Ozark, Missouri 65049, Attn: Mr. M. Atef Sharkawy (Telephone: 314-365-2343).

F. Purpose of Dam:

The dam was constructed primarily for subdivision development for home sites around the lake.

G. Design and Construction History:

The only design information available is a plan of the dam and lake area drawn by Four Seasons Lake Sites. This plan has been redrawn and is included as Sheet 5 of Appendix A to this report. According to Larry Ebersold of Four Seasons Lake Sites, the design of the dam was performed in-house, and was taken from previously designed dams.

The dam was constructed in late 1975 and early 1976 by Mertens Construction Company of Fulton, Missouri. Kenneth Mertens indicated that a core trench was excavated to bedrock along the embankment centerline. Mr. Mertens estimated that the average depth of the trench was about 8 ft. Larry Ebersold indicated that this trench was about 16 ft wide.

Mr. Mertens reported that the material for construction of the dam was taken from the lake area. There is no internal drainage or particular zoning of the embankment. However, Mr. Mertens indicated that an attempt was made to place more select material upstream of the embankment centerline. The embankment material was reportedly rolled with a sheepsfoot compactor.

The only available construction records are the results of several density tests performed by Four Seasons Lake

Sites personnel. The only reported modification to the dam is the recent unauthorized placing of earth on the spillway crest, which effectively raised the lake pool about 1.3 ft. Larry Ebersold indicated that the spillway crest will soon be regraded.

H. Normal Operating Procedures:

The normal flows are discharged through an uncontrolled earth cut spillway located at the left abutment. Information from Larry Ebersold indicates that the dam has never been overtopped. The spillway reportedly operates several times a year, with the maximum flow being about 2 in. deep over the crest.

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 290 acres.

B. Discharge at Dam Site:

- (1) All discharge at the dam site is through an uncontrolled spillway.
- (2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 709.8): 572 cubic feet per second (cfs)
- (3) Estimated Capacity of Primary Spillway: 572 cfs
- (4) Estimated Experienced Maximum Flood at Dam Site: (Elev. 705.2) 6 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 assumed mean sea level elevation of 717.41 for the nail in the root of the 10 in. diameter tree located 15 ft right of centerline at Station 0-30.

- (1) Top of Dam: 709.8 (Low Point); 710.2 (High Point)
- (2) Principal Spillway Crest: 705.0 (Normally), 706.3 (Presently)
- (3) Emergency Spillway Crest: None
- (4) Principal Outlet Pipe Invert: None
- (5) Streambed at Centerline of Dam: 669.8
- (6) Pool on Date of Inspection: 706.3 (with earth placed on spillway crest)
- (7) Apparent High Water Mark: None Apparent
- (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: 2500 ft
- (2) At Spillway Crest: 2300 ft (Elev. 705.0)

E. Storage Capacities:

- (1) At Spillway Crest: 507 ac-ft (Elev. 705.0)
- (2) At Top of Dam: 681 ac-ft

F. Reservoir Surface Areas:

- (1) At Spillway Crest: 31.6 ac. (Elev. 705.0)
- (2) At Top of Dam: 40.6 ac.

G. Dam:

- (1) Type: Earth
- (2) Length at Crest: 740 ft
- (3) Height: 41 ft

- (4) Top Width: 17 ft
- (5) Side Slopes: Upstream 2.7H:1.0V (to water's edge);
Downstream varies (see Sheet 3, Appendix A)
- (6) Zoning: Apparently Homogeneous
- (7) Impervious Core: None
- (8) Cutoff: Key trench to bedrock (16 ft wide, 8 ft deep -
information from Larry Ebersold and Kenneth Mertens).
- (9) Grout Curtain: None

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: Left Abutment
- (2) Type: Earth Cut

I.2 Emergency Spillway:

- (1) Location: Not Applicable
- (2) Type: Not Applicable

J. Regulating Outlets:

There are no regulating outlets associated with Treeline
Lake Dam.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

Mr. Larry Ebersold of Four Seasons Lake Sites indicated that his company had taken the design of Treeline Lakes Dam from previous dams built by that firm. The only available design information is a plan of the embankment and lake (re-drawn as Sheet 5, Appendix A). No design computations or reports are available.

The only construction inspection records are the results of a compaction test and six field density tests performed by the owner. These density tests indicate field densities ranging from 64.5 to 99.5 percent of maximum dry density. The locations of these density tests are not described.

To our knowledge, there are no documented maintenance data.

A. Surveys:

Sheet 5 of Appendix A represents the only evidence of a pre-construction survey that was available. Sheet 3 of Appendix A presents a plan, profile, and cross section of the dam from survey data obtained during the site inspection. A site benchmark elevation of 717.41 for the nail in the root of the 10 in. diameter tree located 15 ft right of centerline at Station 0-30 was used as a reference point for the site survey.

B. Geology and Subsurface Materials:

The site is located in the west-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. The "Geologic Map of Missouri" indicates that the bedrock in the site area consists primarily of the Gasconade formation of the Canadian Series in the Ordovician System. The Gasconade formation is predominantly a light brownish-gray, cherty dolomite. In the central Ozarks region, the average thickness of the Gasconade is 300 ft. Caves and springs are common in this formation.

The publication "Caves of Missouri" indicates that fifteen known caves exist in Camden County; three of these caves are located within 10 miles of the site. In addition, three caves in adjacent Miller County and one cave in adjacent Morgan County are located within 10 miles of the site. The closest known cave is about 6 miles southeast of the site.

The "Geologic Map of Missouri" indicates a normal fault passing about 3 miles northeast of the site in a northwest-southeast 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.

The soils in the area of the dam are of the Clarksville-Fullerton-Talbott soil association. These soils have developed from cherty limestone and dolomite. The thickness of loessial deposits in upland areas may range from 2.5 ft to 5.0 ft.

Information from the Soil Conservation Service indicates that the soils in this area "consist of deep and moderately deep, well drained, moderately permeable soils that formed in clayey residuum weathered from cherty dolomitic limestone bedrock." The predominant Clarksville soils consist of a yellowish-red very cherty, silty clay loam.

C. Foundation and Embankment Design:

No foundation and embankment design information was available. Seepage and stability analyses apparently were not performed as required in the guidelines. There is apparently no particular zoning of the embankment, and no internal drainage features are known to exist.

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 on 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 9.

E. Structure:

There are no structures associated with Treeline Lake Dam.

2.2 CONSTRUCTION:

The only available construction inspection records are the results of a compaction test and six field density tests performed by the owner. There is no indication as to what type of compaction test was performed. These density tests indicate field densities ranging from 64.5 to 99.5 percent of maximum dry density. The test results are summarized in

the following table:

<u>Sample Number</u>	<u>Percent Compaction</u>
1	99.5
2	97.0
3	89.0
4	64.5
5	92.7
6	99.3

The locations of these density tests in the embankment are not described.

2.3 OPERATION:

Normal flows are passed by an uncontrolled earth-cut spillway located in the left abutment. No operating facilities exist.

2.4 EVALUATION:

A. Availability:

The engineering data available are as listed in Section 2.1. No seepage or stability analyses, 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:

Sufficient, valid engineering data on the design or construction of the embankment are not available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on April 28, 1980. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

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

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

B. Dam:

The dam appears to be in generally good condition. Minor erosion channels were observed on the downstream face of the dam. In addition, rutting and erosion caused by vehicular traffic on the downstream embankment face was noted (see Photos 11 and 12). Some seepage ($\pm 1/2$ gpm) was observed from an area about mid-height on the downstream right abutment-dam contact. The water from this seepage area was flowing clear, but has developed a small erosion channel down the right abutment-dam contact. Although no brush or tree growth was noted, the embankment was covered with high weeds, which made it difficult to inspect.

A large wet, soft, marshy area is located at the downstream embankment toe in the valley floor. The presence of iron oxide staining indicates that the marshy condition is probably due to seepage. No significant flows from this area were observed. No wave protection is provided for the upstream face of the dam, although no erosion or sloughing was observed. The horizontal and vertical alignments of the crest appeared good, and no surface cracking or unusual movement was obvious. Shallow auger probes into the embankment indicated the dam to consist of a reddish brown sandy clay with some silt and chert fragments. Information from Kenneth Mertens indicates that material for construction of the dam was obtained from the lake area.

C. Appurtenant Structures:

C.1 Primary Spillway:

The approach area to the spillway was clear. The spillway crest has been raised about 1.3 ft by placing earth across the spillway. Larry Ebersold reported that this was done by unauthorized persons, and that the owner intends to regrade the spillway crest. No non-erodible control section exists for the spillway. The spillway outlet cascades down the wooded left abutment and into the valley, well away from the embankment. No significant erosion was noted in the outlet area.

C.2 Emergency Spillway:

There is no emergency spillway associated with Treeline Lake Dam.

D. Reservoir:

The watershed is generally wooded with no agricultural activity. Homes are to be constructed around the lake. The slopes adjacent to the reservoir are moderate to steep, and no sloughing or serious erosion was noted. The reservoir water was clear, and no serious sedimentation problems were noted.

E. Downstream Channel:

The downstream channel is wide and fairly clear. The Lake of the Ozarks is located several hundred yards downstream of the dam (see Photo 15).

3.2 EVALUATION:

The dam appears to be in good condition. The high weed growth on the dam can provide shelter for small animals and encourage burrowing. The seepage from the right abutment-dam contact and the apparent seepage area beyond the embankment toe could adversely affect the stability of the dam. The erosion on the downstream embankment face could worsen and also affect the embankment stability. Due to the lack of a non-erodible spillway control section, sustained flows could erode the spillway and effectively lower the normal pool of the lake. These deficiencies should be corrected under the direction of an engineer experienced in the design and construction of dams.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

There are no operating facilities associated with this dam. The pool is normally controlled by rainfall, runoff, evaporation, the capacity of the uncontrolled spillway, and seepage from the reservoir.

4.2 MAINTENANCE OF DAM:

The presence of high weed growth and eroded areas on the embankment indicates that the dam has not been maintained recently.

4.3 MAINTENANCE OF OPERATING FACILITIES:

There are no operating facilities for this dam.

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 erosion of the embankment face, seepage from the right embankment-abutment contact and beyond the embankment toe, high weed growth on the dam, and lack of a non-erodible spillway control section are serious deficiencies which should be corrected. However, to avoid creating an unsafe condition, these deficiencies should only be corrected under the direction of an engineer experienced in the design and construction of dams.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. Design Data:

No hydrologic or hydraulic design computations for this dam and reservoir were available.

B. Experience Data:

No recorded rainfall, runoff, discharge, or reservoir stage data were available for this reservoir and watershed. Larry Ebersold indicated that the dam has never overtopped. The spillway operates periodically, and the maximum reported depth of water over the spillway is about 2 in. At the time of the inspection, the pool level was approximately 1.3 ft above normal pool due to unauthorized placing of soil on the spillway crest. No high water marks or indication of overtopping was observed.

C. Visual Observations:

The approach channel to the spillway is clear. The elevation of the reservoir pool has been raised about 1 ft by placing soil in the spillway control section. The spillway outlet channel cascades down the wooded left abutment to the valley floor. The spillway is well separated from the embankment, and spillway releases would not be expected to endanger the dam.

D. Overtopping Potential:

The hydraulic and hydrologic analyses (using the U. S. Army Corps of Engineers guidelines and the computer program HEC-1) were based on: (1) a field survey of the reservoir storage and spillway dimensions and embankment elevations and (2) an estimate of the pool and drainage areas from the Lake Ozark, Missouri, 7.5 minute U.S.G.S. quadrangle map (1959). These analyses assume that flood flows will quickly lower the spillway crest to the normal elevation of 705.0.

Based on the hydrologic and hydraulic analysis presented in Appendix C, the spillway will pass 45 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 spillway will pass the 1 percent probability flood without overtopping the dam.

Application of the Probable Maximum Precipitation (PMP), minus losses, resulted in a flood hydrograph peak inflow of 6,349 cfs. For 50 percent of the PMP, the peak inflow was 3,175 cfs. The routing of the PMF through the spillway and dam indicates that the dam will be overtopped by 1.6 ft at elevation 711.4. The duration of the overtopping will be 4.3 hours, and the maximum outflow will be 4,641 cfs. The maximum discharge capacity of the spillway is 572 cfs. The routing of 50 percent of the PMF indicates that the dam will be overtopped by 0.4 ft at elevation 710.2. The duration of overtopping will be 1.6 hours, and the maximum outflow will be 947 cfs. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of 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:

Available design and construction data for Treeline Lake Dam are discussed in Sections 2.1 and 2.2. These data are considered inadequate to evaluate the structural stability of the dam. 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:

There are no operating facilities for this dam.

D. Post-Construction Changes:

The only reported post-construction change was the unauthorized placing of soil in the spillway control section which raised the reservoir pool about 1.3 ft.

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 good condition. Several items were noted during the visual inspection which should be investigated further, corrected or controlled. These items are: (1) high weed growth on both embankment faces; (2) several minor erosion channels and evidence of vehicular traffic on the downstream embankment face; (3) seepage and erosion at the downstream right abutment-dam contact; (4) wet, marshy area at and beyond the downstream embankment toe; (5) lack of a non-erodible spillway control section; and (6) lack of wave protection for the upstream embankment face.

Another deficiency was the lack of seepage and stability analysis records.

The dam will be overtopped by flows in excess of 45 percent of the Probable Maximum Flood with the spillway at elevation 705.0. 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 review of the information listed in Section 2.1, the performance history as related by others, 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 continue to deteriorate and possibly could become serious in the future. The item recommended in paragraph 7.2A should be pursued promptly.

D. Necessity for Additional Inspection:

Based on the result of the Phase I inspection, no additional 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.

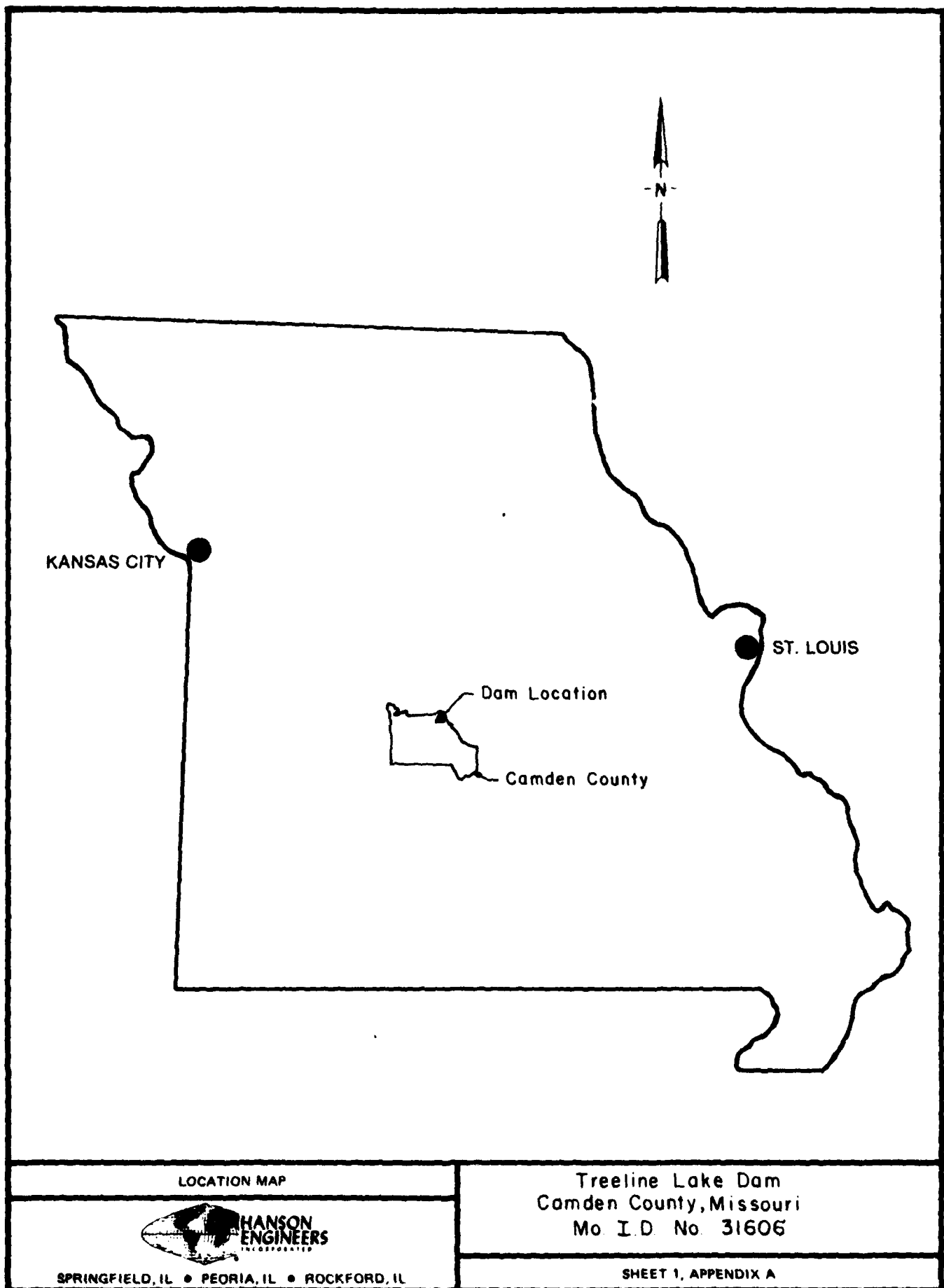
B. O&M Procedures:

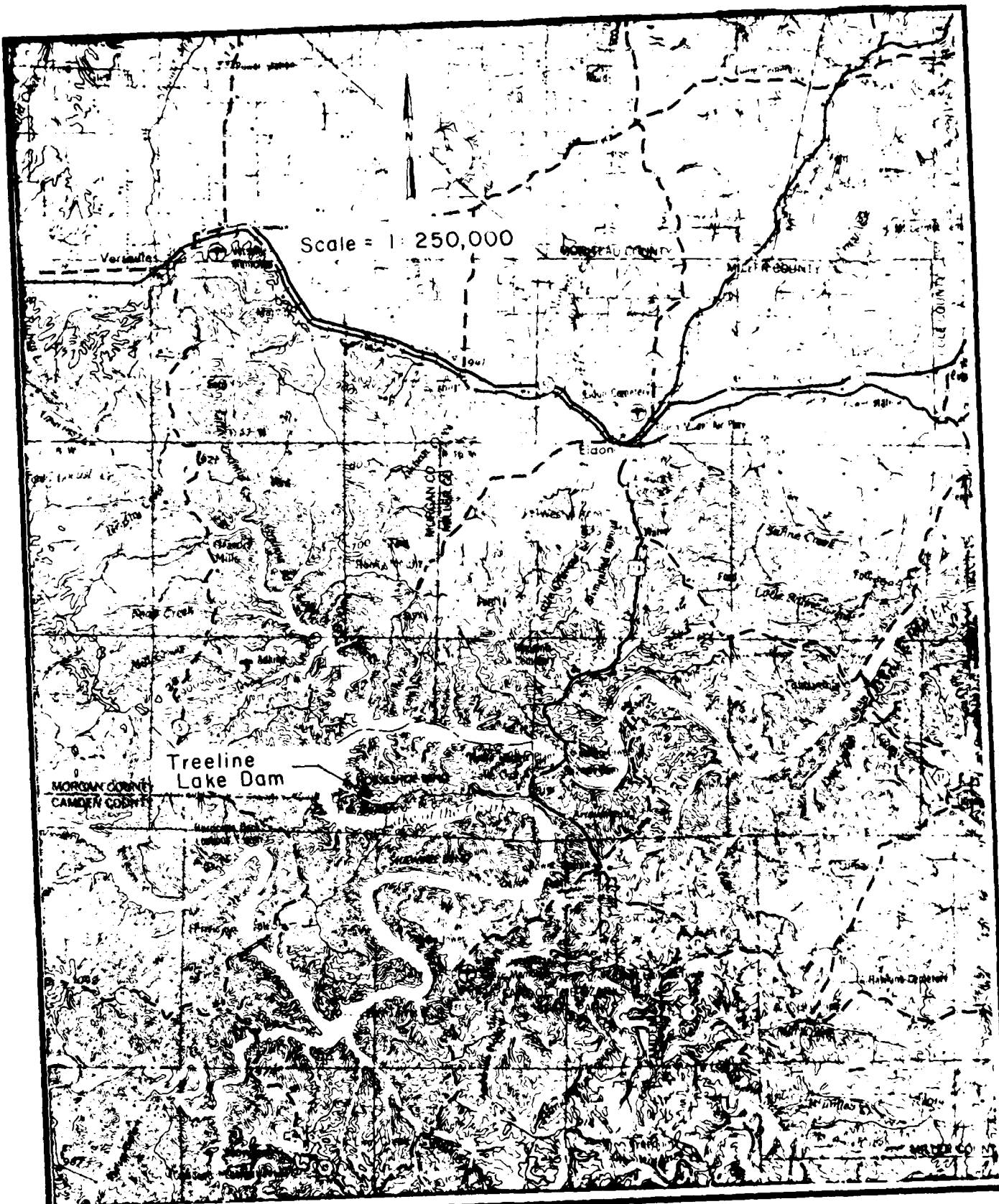
- (1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the construction of dams.
- (2) The seepage areas at the downstream right abutment-dam contact and at the downstream embankment toe should be investigated by an engineer experienced in the design and construction of dams. Remedial measures may be required. As a minimum, the marshy area should be drained and monitored to determine if there is any increase in quantities and whether soil particles are being carried with the water.
- (3) Erosional areas and areas of rutting should be repaired and seeded. Measures should be taken to prevent vehicular access to the embankment face.
- (4) A non-erodible spillway control section should be provided so that progressive erosion of the spillway will not lower the normal pool of the reservoir.

- (5) Wave protection should be provided for the upstream face of the dam.
- (6) The vegetative growth on the dam should be cut as often as necessary to allow a proper inspection of the dam faces.
- (7) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

APPENDIX A

Dam Location and Plans





VICINITY MAP



HANSON
ENGINEERS
INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Treeline Lake Dam
Camden County, Missouri
Mo. I D. No. 31606

Sheet 2, Appendix A

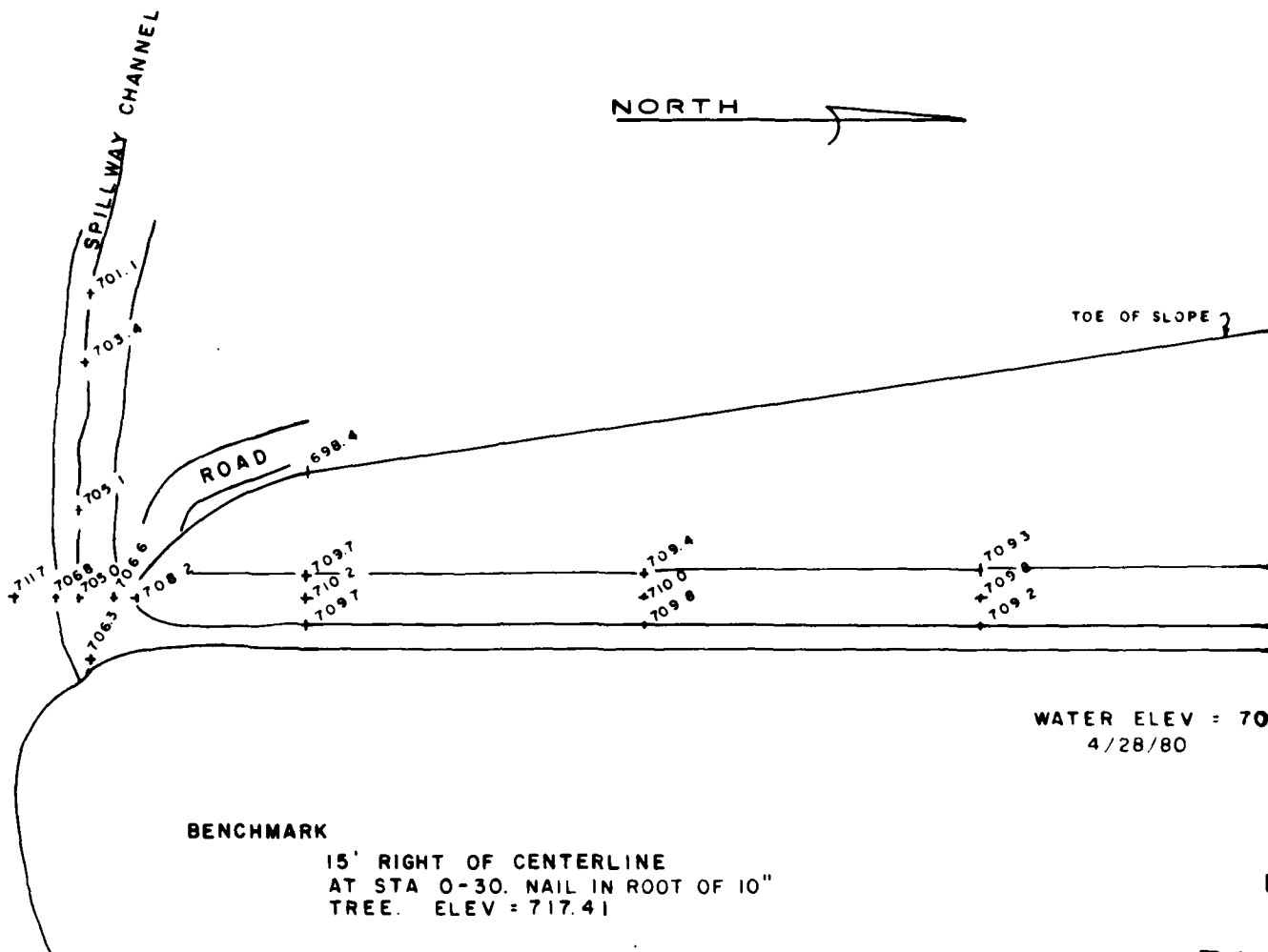
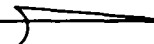
8+00

7+00

6+00

5+00

NORTH



WATER ELEV = 70
4/28/80

BENCHMARK

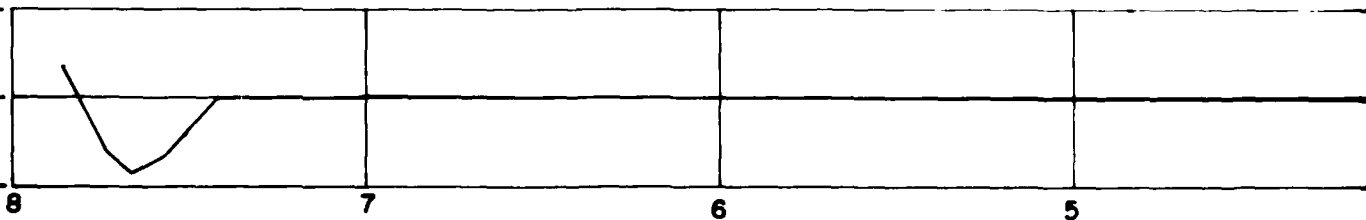
15' RIGHT OF CENTERLINE
AT STA 0-30. NAIL IN ROOT OF 10"
TREE. ELEV = 717.41

PL

715

710

705



4+00

3+00

2+00

1+00

A

TOE OF SLOPE

669.8

697.9

688.3

ROAD

709.7
710.0
709.6

709.5
709.8
709.3

709.0
709.9
709.1

700.9
709.5
710.0
709.6

EDGE OF WATER

WATER ELEV. = 706.3
4/28/80

A

LAKE

PLAN VIEW

SCALE 1" = 50'

4

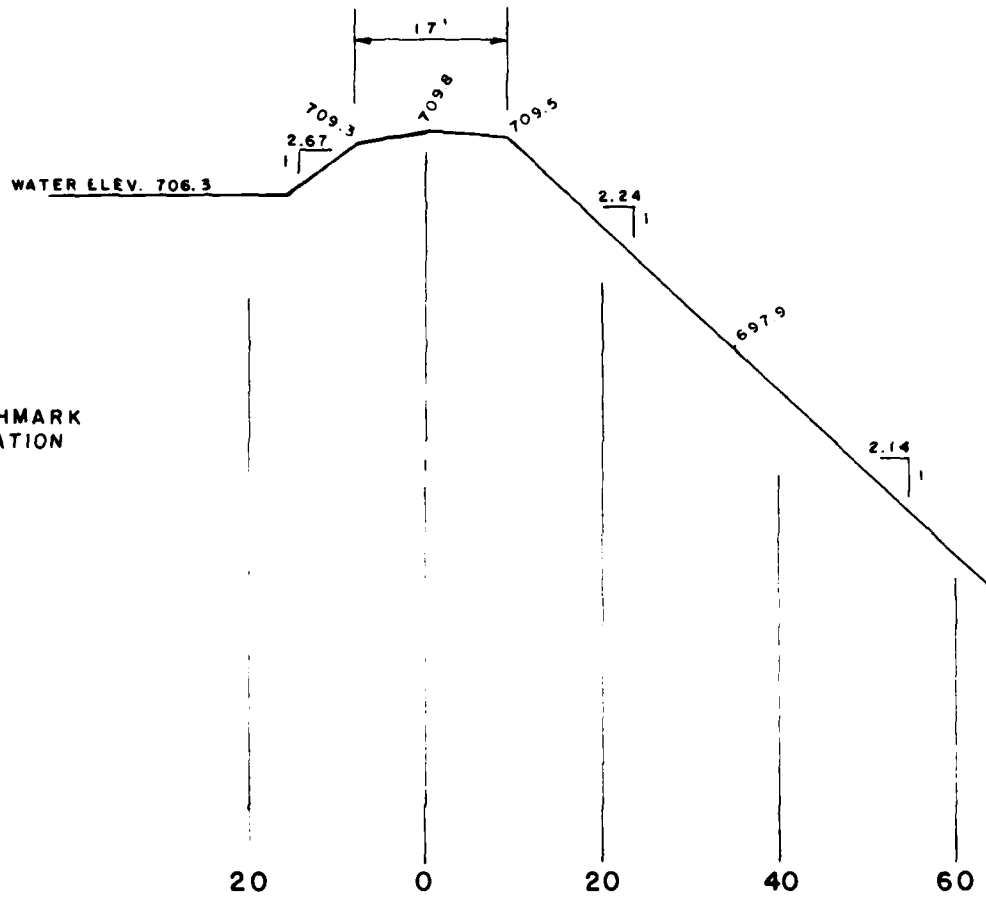
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2

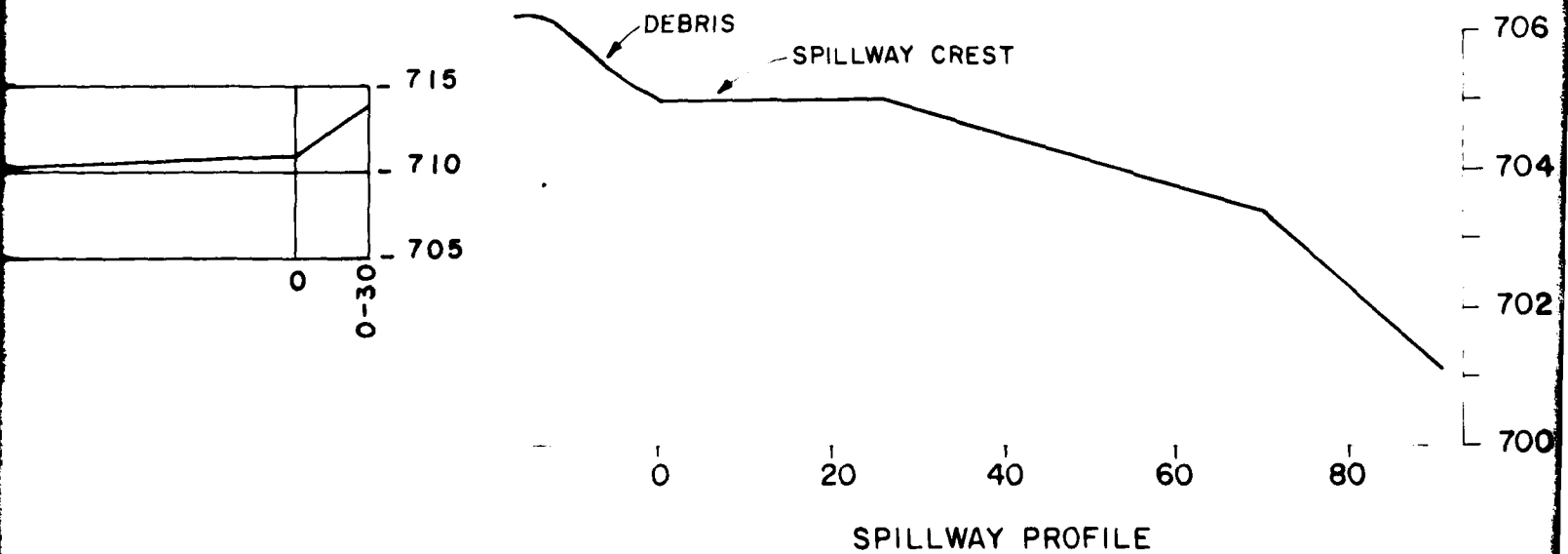
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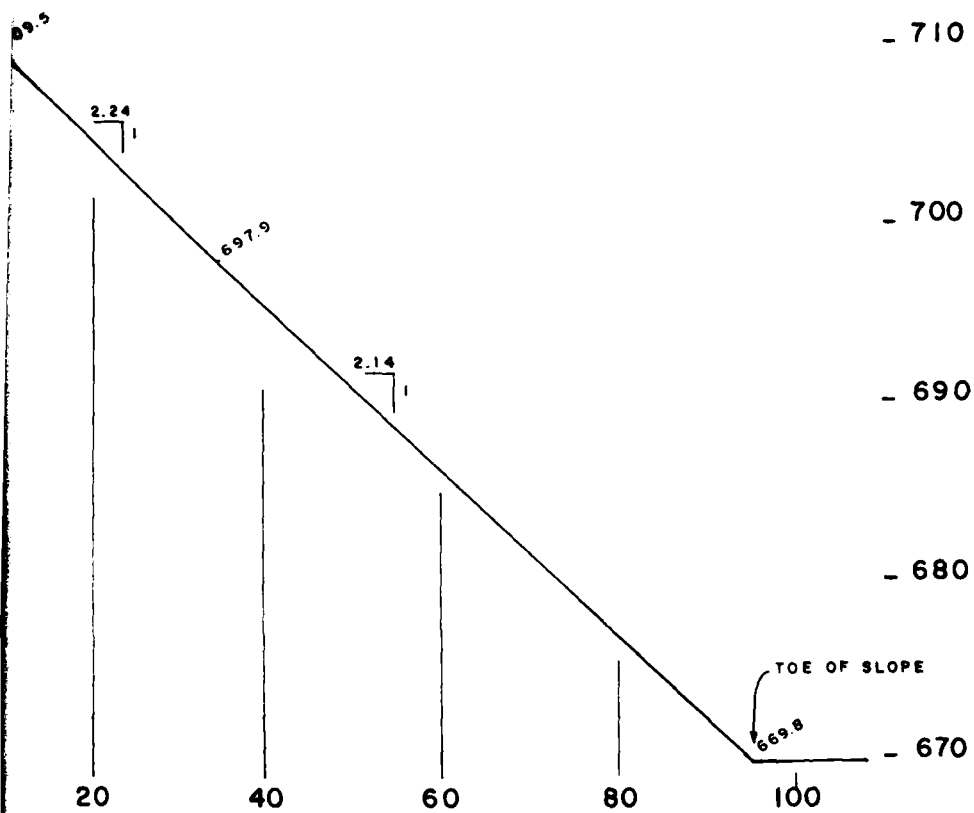
PROFILE

0+00

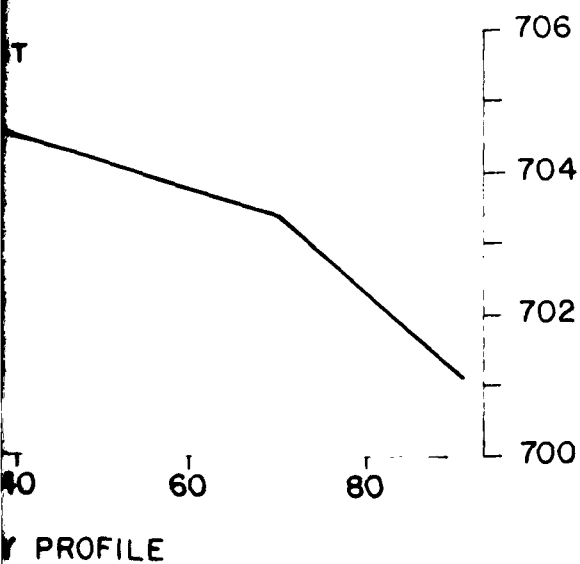


SECTION A-A STA 3+00





A-A STA 3+00



SHEET 3 APPENDIX A

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

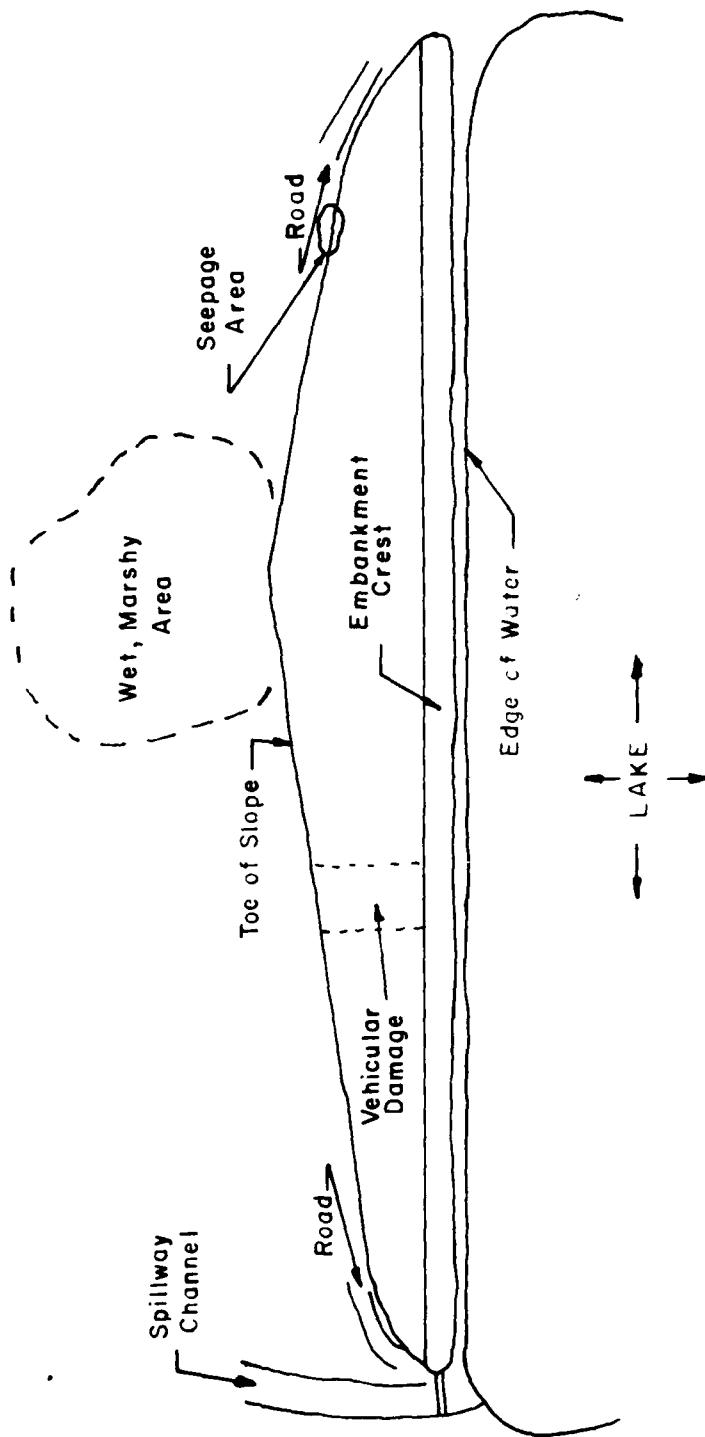
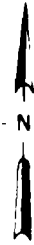
TREELINE LAKE DAM

MO. No. 31606

PLAN & PROFILE

CAMDEN COUNTY, MO.

4



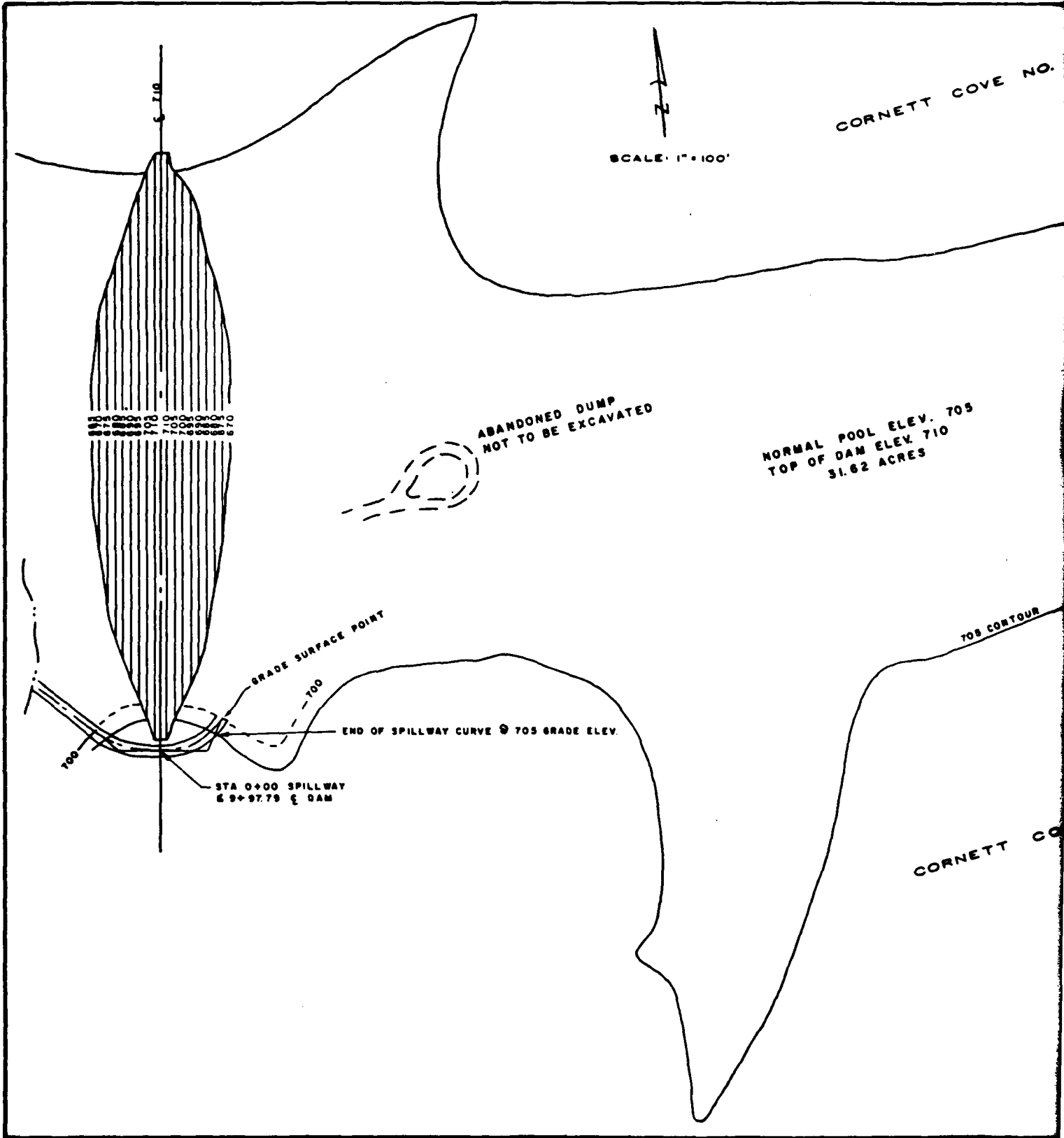
PLAN SKETCH OF FEATURES



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Treeline Lake Dam
Camden County, Missouri
Mo. I.D. No. 31606

Sheet 4 , Appendix A



CORNETT COVE NO.

SCALE: 1" = 100'

ABANDONED DUMP
NOT TO BE EXCAVATED

NORMAL POOL ELEV. 705
TOP OF DAM ELEV. 710
31.62 ACRES

GRADE SURFACE POINT

END OF SPILLWAY CURVE @ 705 GRADE ELEV.

STA 0+00 SPILLWAY
& 9+97.79 @ DAM

705 CONTOUR

CORNETT CO

DRAWINGS AND SPECIFICATIONS

EARTH DAM

LAND OF THE FIFTH SEASON
LAKE OZARK, MO.

COVE NO. 1

705 CONTOUR

705
0

705 CONTOUR

ARNETT COVE NO. 2

SHEET 5 OF APPENDIX A

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

TREELINE LAKE

NO. NO. 31806

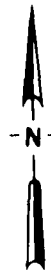
PLAN

CANDLER COUNTY, MO.

REDRAWN FROM DATA SHEET
OBTAINED BY OWNER

APPENDIX B

Geology and Soils



LEGEND

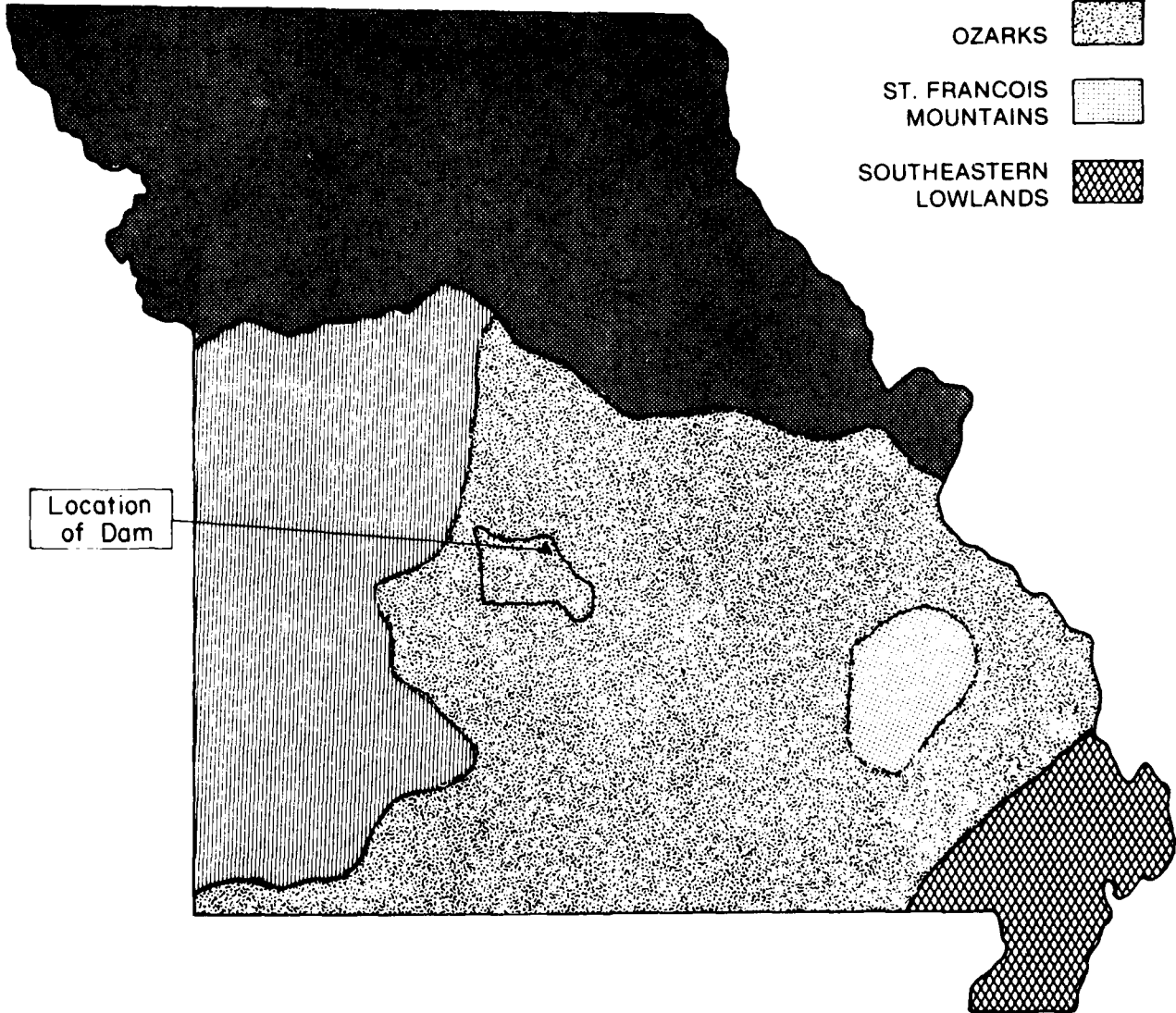
GLACIATED PLAINS 

WESTERN PLAINS 

OZARKS 

ST. FRANCOIS MOUNTAINS 

SOUTHEASTERN LOWLANDS 



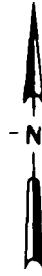
MAJOR GEOLOGIC REGIONS OF MISSOURI



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

TreeLine Lake Dam
Camden County, Missouri
Mo I.D. No. 31606

SHEET 1, APPENDIX B



FEET

20 +



10-20



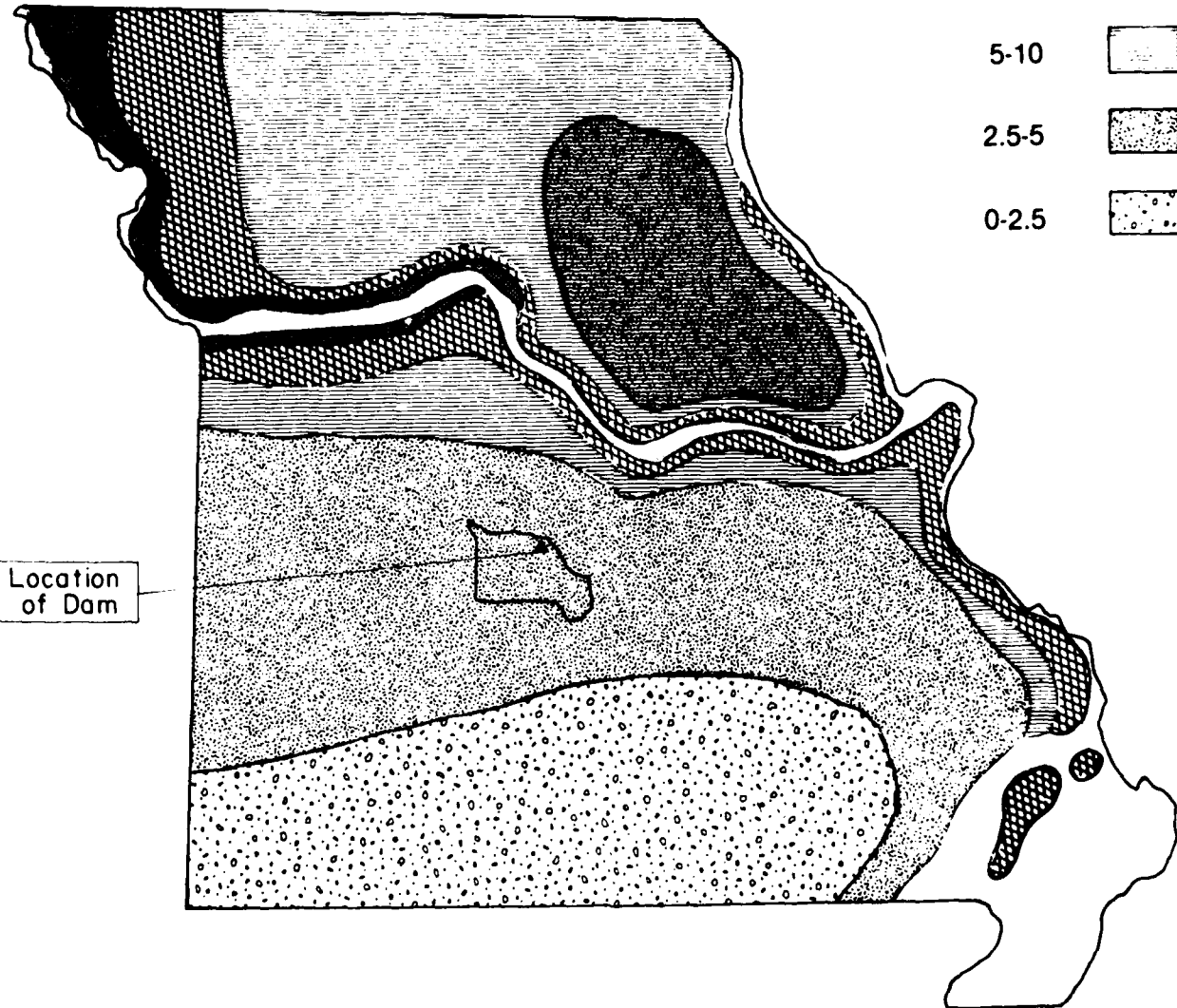
5-10



2.5-5



0-2.5



Location
of Dam

THICKNESS OF LOESSIAL DEPOSITS



HANSON
ENGINEERS
INCORPORATED

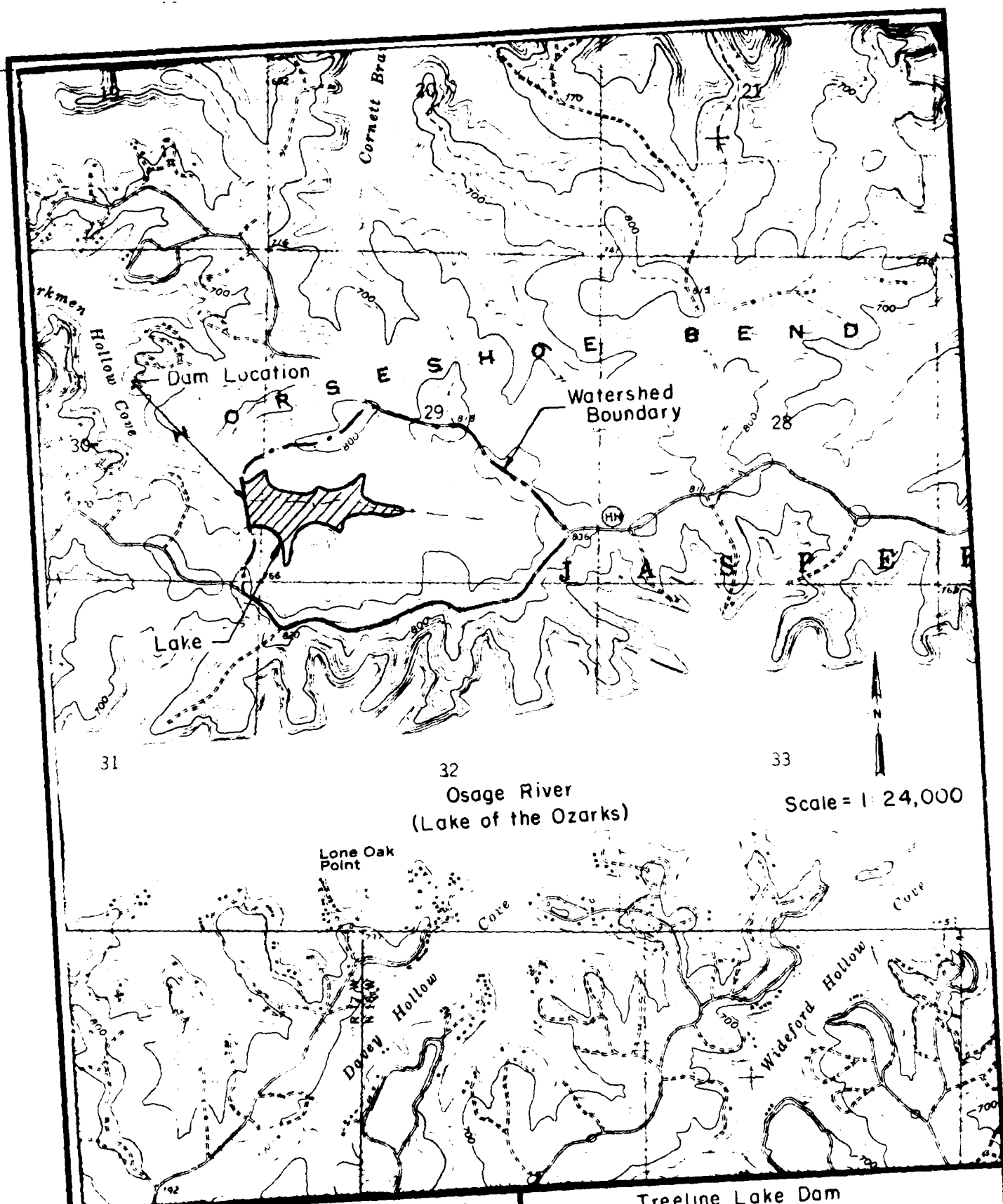
SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Treeline Lake Dam
Camden County, Missouri
Mo. I.D. No. 31606

SHEET 2, APPENDIX B

APPENDIX C

Overtopping Analysis



LAKE AND WATERSHED MAP



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Treeline Lake Dam
Camden County, Missouri
Mo I D No 31606

Sheet 1, Appendix C

APPENDIX C

HYDROLOGIC AND HYDRAULIC ANALYSIS

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was accomplished using the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California.

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." Reduction factors were not applied. The rainfall distribution for the 24-hour PMP storm duration was assumed according to the procedures outlined in EM 1110-2-1411 (SPD Determination). Also, the 1 percent chance probability flood was routed through the reservoir and spillway. Warsaw rainfall distribution, as provided by the St. Louis District, Corps of Engineers, was used in this case.

The synthetic unit hydrograph for the watershed was developed by the computer program using the SCS method. The parameters for the unit hydrograph are shown in Table 1 (Sheet 3, Appendix C).

The SCS curve number (CN) method was used in computing the infiltration losses for rainfall-runoff relationship. The CN values used, and the result from the computer output, are shown in Table 2 (Sheet 4, Appendix C).

The reservoir routing was accomplished by using the Modified Puls Method. The hydraulic capacity of the spillway was used as an outlet control in the routing. The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation-surface area--storage-discharge relationships shown in Table 3 (Sheet 4, Appendix C).

The rating curve for the spillway (see Table 4, Sheet 5, Appendix C) was determined assuming critical flow over a broad-crested weir.

The flow over the crest of the dam during overtopping was determined using the non-level dam option (\$L and \$V cards) of the HEC-1 program. The program assumes critical flow.

A summary of the routing analysis for different ratios of the PMF is shown in Table 5 (Sheet 6, Appendix C).

The computer input data, a summary of the output data, and a plot of the inflow-outflow hydrograph for the PMF are presented on Sheets 7, 8 and 9 of Appendix C.

TABLE 1
SYNTHETIC UNIT HYDROGRAPH

Parameters:

Drainage Area (A)	0.45 sq. miles
Length of Watercourse (L)	0.50 miles
Difference in elevation (H)	131 feet
Time of concentration (Tc)	0.18 hours
Lag Time (Lg)	0.11 hours
Time to peak (Tp)	0.15 hours
Peak Discharge (Qp)	1452 cfs
Duration	5 min.

<u>Time (Min.)(*)</u>	<u>Discharge (cfs)(*)</u>
0	0
5	814
10	1429
20	300
25	50
30	20
35	9
40	1

(*) From the computer output

FORMULA USED:

$$T_c = \left(\frac{11.9 L^3}{H} \right)^{0.385}$$

$$L_g = 0.6 T_c$$

$$T_p = \frac{D}{2} + L_g$$

$$Q_p = \frac{484 A \cdot Q}{T_p} \quad Q = \text{Excess Runoff} = 1 \text{ inch}$$

TABLE 2
RAINFALL-RUNOFF VALUES

<u>Selected Storm Event</u>	<u>Storm Duration (Hours)</u>	<u>Rainfall (Inches)</u>	<u>Runoff (Inches)</u>	<u>Loss (Inches)</u>
PMP	24	33.41	30.63	2.78
100-year	24	7.69	3.66	4.04

Additional Data:

- 1) Soil Conservation Service Soil Group B
- 2) Soil Conservation Service Runoff Curve CN = 78 (AMC III) for the PMF
- 3) Soil Conservation Service Runoff Curve CN = 60 (AMC II) for the
1 percent chance flood
- 4) Percentage of Drainage Basin Impervious 12 percent

TABLE 3
ELEVATION, SURFACE AREA, STORAGE AND DISCHARGE RELATIONSHIPS

<u>Elevation (feet-MSL)</u>	<u>Lake Surface Area (acres)</u>	<u>Lake Storage (acre-ft)</u>	<u>Spillway Discharge (cfs)</u>
670	0	0	-
680	5	25	-
690	16	130	-
700	29	355	-
*705	31.6	507	0
**709.8	40.6	681	572
720	54	1163	-

*Primary spillway crest elevation

**Top of dam elevation

The above relationships were developed using the Lake Ozark, MO
7.5 minute quadrangle map and the field measurements.

TABLE 4

SPILLWAY RATING CURVE

<u>Reservoir Elevation</u> (M.S.L.)	<u>Primary Spillway Flow</u> (c.f.s.)
705.0	0
706.0	28
707.0	99
708.0	218
709.0	391
*709.8	572
711.0	924
712.0	1295

*Top of dam elevation

Formula Used: $Q = C_2 \cdot b \cdot H_m^{1.5}$

Q = Discharge in cfs

C_2 = Discharge coefficient from Table 8-7 page 8-58 (Handbook of Hydraulics by King-Brater)

b = bottom width of spillway channel

H_m = energy head

TABLE 5
RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (cfs)	Peak Lake Elevation (ft.-MSL)	Total Storage (ac-ft.)	Peak Outflow (cfs)	Depth (ft.) Over Top of Dam
	0	*705.0	507	0	-
0.10	635	707.46	560	61	-
0.20	1270	707.59	601	169	-
0.30	1905	708.56	636	314	-
0.40	2540	709.48	669	500	-
0.45	2857	**709.8	681	572	0
0.50	3175	710.18	696	947	0.38
0.60	3810	710.53	713	1720	0.73
0.75	4762	710.93	732	2946	1.13
1.00	6349	711.36	753	4641	1.56

The percentage of the PMF that will reach the top of the dam is 45 percent.

*Primary spillway crest elevation

**Top of dam elevation

[illegible]

Sheet 7 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)

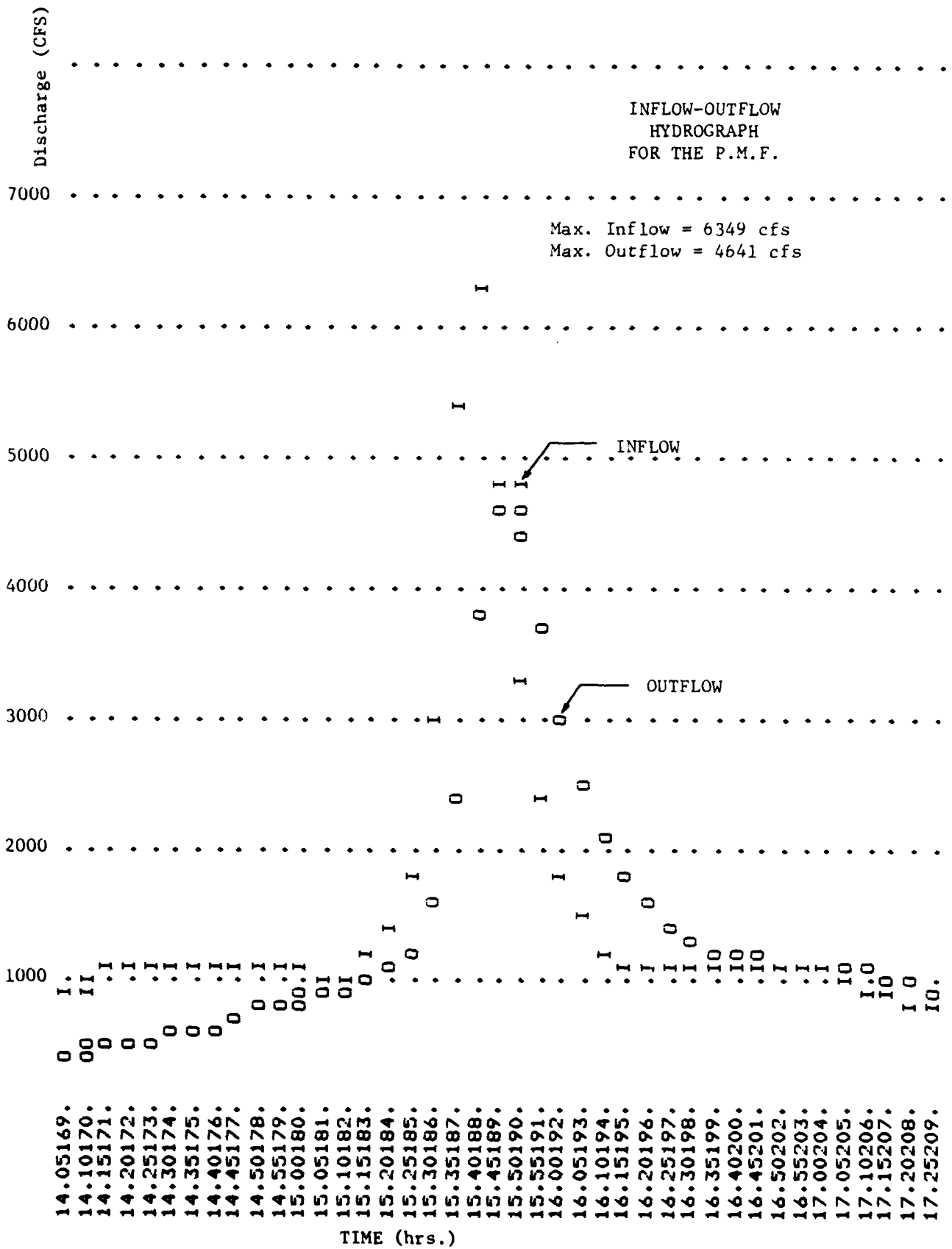
OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS							
				RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8
HYDROGRAPH AT	1	0.45	1	0.10	0.20	0.30	0.40	0.50	0.60	0.75	1.00
	(1.17)	(1.17)	(1.17)	(17.98)	(35.96)	(53.94)	(71.92)	(89.90)	(107.88)	(134.84)	(179.79)
ROUTED TO	2	0.45	1	0.10	0.20	0.30	0.40	0.50	0.60	0.75	1.00
	(1.17)	(1.17)	(1.17)	(17.98)	(35.96)	(53.94)	(71.92)	(89.90)	(107.88)	(134.84)	(179.79)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1				INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION				705.00	705.00	709.80
STORAGE				507.	507.	681.
OUTFLOW				0.	0.	572.

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
0.10	706.46	0.00	560.	61.	0.00	18.17	0.00
0.20	707.59	0.00	601.	169.	0.00	17.33	0.00
0.30	708.56	0.00	636.	314.	0.00	17.00	0.00
0.40	709.48	0.00	669.	500.	0.00	16.17	0.00
0.50	710.18	0.38	696.	947.	1.58	16.00	0.00
0.60	710.53	0.73	713.	1720.	2.42	15.92	0.00
0.75	710.93	1.13	732.	2946.	3.00	15.83	0.00
1.00	711.36	1.56	753.	4641.	4.25	15.75	0.00

PMF RATIOS
 OUTPUT DATA

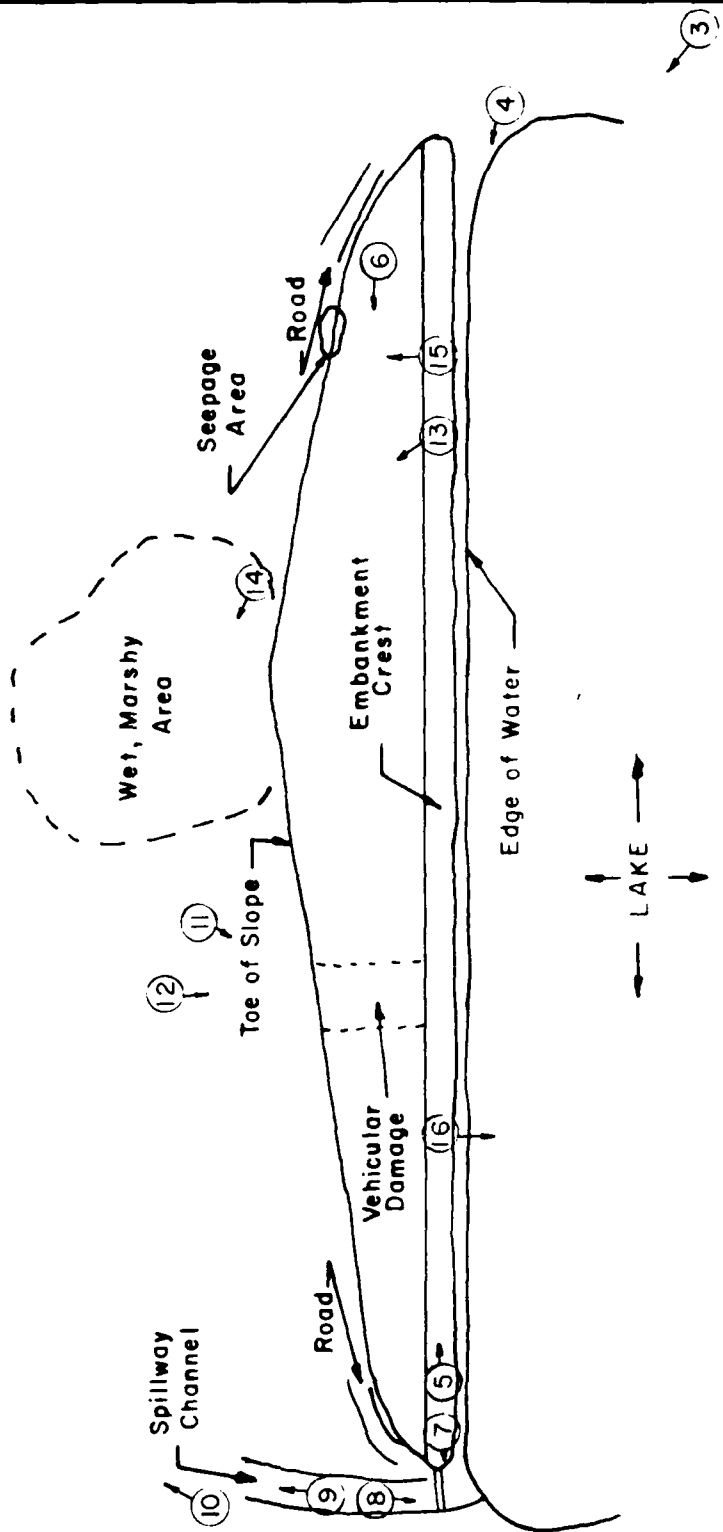
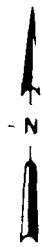


APPENDIX D

Photographs

LIST OF PHOTOGRAPHS

<u>Photo No.</u>	<u>Description</u>
1.	Aerial View of Dam
2.	Overall View of Dam from Left Abutment
3.	Overall View of Dam from Right Abutment
4.	Upstream Face of Dam - Looking Toward Left Abutment.
5.	Crest of Dam - Looking Toward Right Abutment
6.	Downstream Face of Dam - Looking Toward Left Abutment.
7.	View of Spillway Crest
8.	View of Spillway - Looking Upstream
9.	View of Spillway - Looking Downstream
10.	Spillway Outlet Channel - Looking Downstream
11.	Erosion and Rutting of Downstream Face
12.	Close-Up of Vehicle Damage to Downstream Face
13.	Overview of Wet, Marshy Area at Downstream Toe
14.	Close-Up of Portion of Marshy Area
15.	View of Downstream Features
16.	View of Lake and Watershed Area



PHOTOGRAPH LOCATIONS



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Treeline Lake Dam
Camden County, Missouri
Mo. I. D. No. 31606

Sheet 2, Appendix D

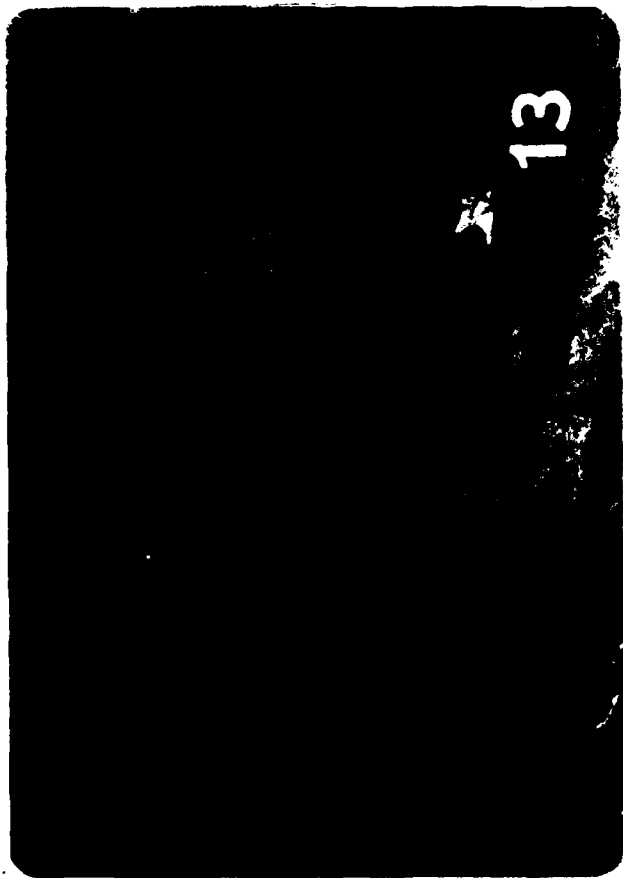








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DATE
FILME