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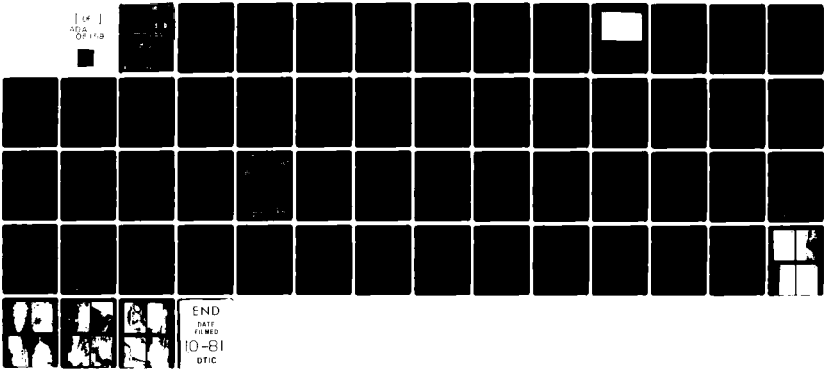

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OSAGE-GASCONADE RIVER BASIN

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WINDSOR FARRINGTON PARK LAKE DAM

PETTIS COUNTY, MISSOURI

MO 20034

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

AUGUST, 1980

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7. AUTHOR(s) Anderson Engineering, Inc. Steven L. /Brady Jack /Healy Gene /Wertepny Tom /Beckley Brad /Parrish	8. CONTRACT OR GRANT NUMBER(s) DACW43-80-C-0073
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18. SUPPLEMENTARY NOTES	
19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)* Dam Safety, Lake, Dam Inspection, Private Dams	
20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)* This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.	

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☆ U.S. G.P.O. 1980-665-141/1299

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Windsor Farrington Park Lake Dam
Pettis County, Missouri
Missouri Inventory No. 20034

This report presents the results of field inspection and evaluation of the Windsor Farrington Park Lake Dam. 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: SIGNED
Chief, Engineering Division — 3 NOV 1980 — Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer — 4 NOV 1980 — Date

OSAGE-GASCONADE RIVER BASIN

WINDSOR FARRINGTON PARK LAKE DAM
PETTIS COUNTY, MISSOURI
MISSOURI INVENTORY NO. 20034

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

AUGUST, 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
SUMMARY

Name of Dam: Windsor Farrington Park Lake Dam
State Located: Missouri
County Located: Pettis
Stream: Tributary of Elm Branch
Date of Inspection: July 16, 1980

Windsor Farrington Park 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 this 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 several dwellings and outbuildings and a sewage treatment plant.

The dam is in the small size classification, since it is greater than 25 ft high but less than 40 ft high, and the maximum storage capacity is greater than 50 ac-ft but less than 1,000 ac-ft.

~~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 32 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 small size with a high downstream hazard potential pass 50 to 100 percent of the PMF. Considering the height of dam (26 feet) and the maximum storage capacity (250 acre-feet), 50 percent

of the PMF has been determined to be the appropriate spillway design flood. The 100-year flood (1 percent probability flood) will not overtop the dam. The 1 percent probability flood is one that has a 1 percent chance of being equalled or exceeded in any given year.

The dam appears to be in fair condition. Deficiencies visually observed by the inspection team were: (1) minor surface cracking in the crest of the dam; (2) considerable sloughing along upstream face of embankment; (3) irregular vertical alignment of the crest; (4) considerable erosion on the embankment; (5) thick growth of trees and brush on the embankment; (6) some large trees in the downstream channel; and (7) minor leakage through the concrete arch culvert.

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

It is recommended that the owners take the necessary action without undue delay to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.

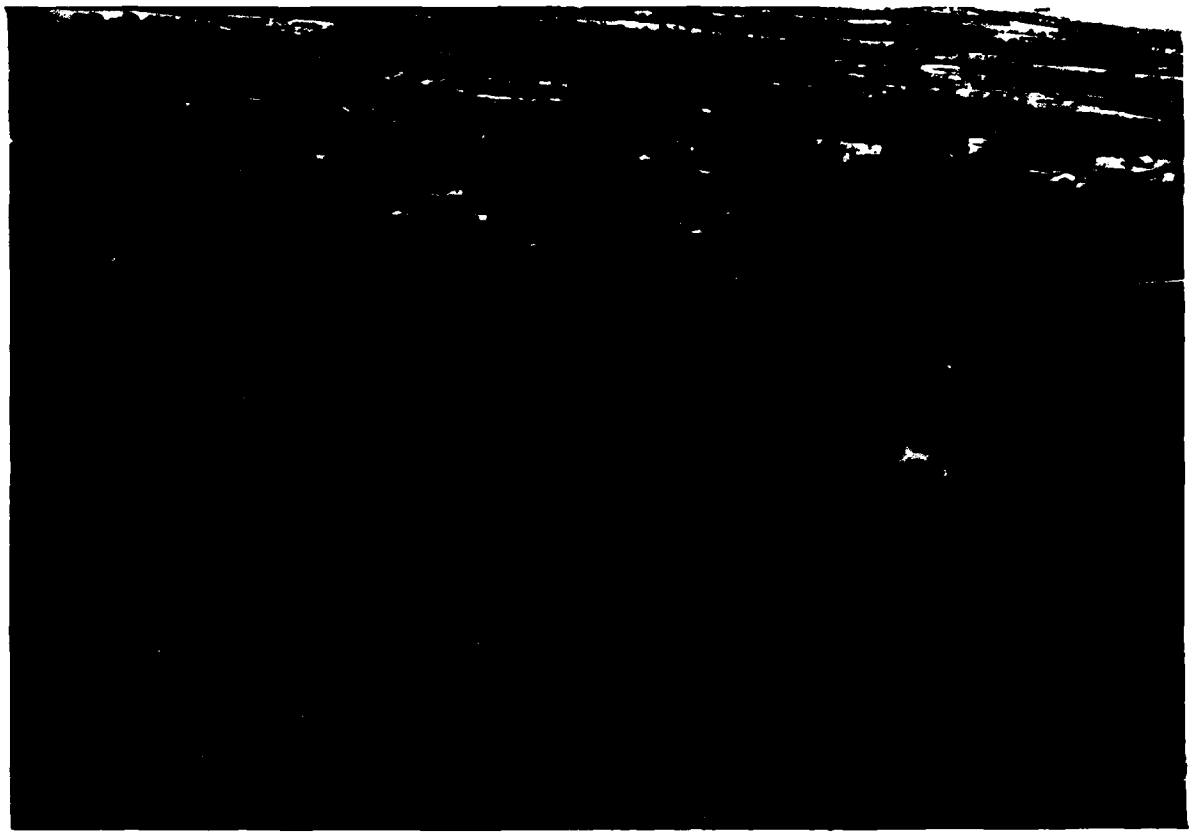
Steven L. Brady, P.E.
Anderson Engineering, Inc.

For Jack Healy, P.E.
Hanson Engineers, Inc.

Gene Wertepny, P.E.
Hanson Engineers, Inc.

Tom Beckley, P.E.
Anderson Engineering, Inc.

Brad Parrish, E.I.T.
Anderson Engineering, Inc.



AERIAL VIEW OF LAKE AND DAM

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
WINDSOR FARRINGTON PARK LAKE DAM
MISSOURI INVENTORY NO. 20034

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APPENDICES

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 Windsor Farrington Park Lake Dam in Pettis 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:

Windsor Farrington Park Lake Dam is an earth fill structure approximately 26 ft high and 1,230 ft long at the crest. The appurtenant works consist of a 14 x 14 ft wide concrete inlet structure, 16.5 ft deep opening into a formed concrete arch culvert through the embankment.

Sheet 3 of Appendix A shows a plan, profile, and typical section of the embankments and details of the inlet structure and the arch culvert.

B. Location:

The dam is located in the southwestern part of Pettis County, Missouri on a tributary of Elm Branch. The dam and lake are within the Windsor, Missouri 7.5 minute quadrangle sheet (Section 06, T43N, R23W - latitude 38°31.6'; longitude 93°30.5'). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 26 ft and a maximum storage capacity of approximately 250 acre-ft, the dam is in the small size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has classified this dam as a potential high hazard dam. The estimated damage zone extends approximately two miles downstream of the dam. Located within this zone are several dwellings and outbuildings and a sewage treatment plant. The affected items within the damage zone were verified by the inspection team.

E. Ownership:

The dam is owned by the City of Windsor. The owner's address is Windsor, Missouri, Attn: Mr. Carter Oakes, Park Board Chairman.

F. Purpose of Dam:

The dam was constructed primarily for a source of water supply for the Rock Island Railroad.

G. Design and Construction History:

Information obtained indicates that the dam was constructed in 1902 by the Rock Island Railroad. No design information or plans were available. The dam was deeded to the City of Windsor in 1954 by the Rock Island Railroad. The lake was drained in 1955. At that time, the concrete inlet structure had minor surfacing repairs, and the lake was dredged. The material from the dredging operation was used to construct the "fingers" extending into the reservoir area (see Photograph No. 3) and the embankment near the east end of the dam, forming a small triangular shaped pond. A 6 inch diameter cast-iron pipe was installed through the embankment. Mr. Oakes and Mr. Leonard May, resident caretaker of the park, stated that the purpose of the small pond to the east of the lake was to raise fish for stocking the lake. They indicated the pond had not been used for that purpose for many years.

No additional modifications to the dam have been reported.

H. Normal Operating Procedures:

All flows will be passed by the uncontrolled concrete inlet structure through the concrete arch culvert. Information obtained from Mr. Oakes indicates that the dam has not been overtopped. He stated that in 1972 the water level was about 30 inches above the spillway crest (Elevation 858.5).

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 775 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. 860.5): 1,670 cfs

(3) Estimated Capacity of Principal Spillway: 1,670 cfs (Elev. 860.5)

(4) Estimated Experience Maximum Flood at Dam Site: 620 cfs (Elevation 858.5)

(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 856.0 for top of concrete inlet structure (normal pool elevation) (estimated from quadrangle map).

(1) Top of Dam: 860.5 feet, MSL

(2) Principal Spillway Crest: 856.0 feet, MSL

(3) Emergency Spillway Crest: Not Applicable

(4) Principal Outlet Pipe Invert: Not Applicable

(5) Streambed at Centerline of Dam: 836.0 feet, MSL

(6) Pool on Date of Inspection: 855.4 feet, MSL

(7) Apparent High Water Mark: None

(8) Maximum Tailwater: Not Applicable

(9) Upstream Portal Invert Diversion Tunnel: Not Applicable

(10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

(1) At Top of Dam: 4,000 feet

(2) At Emergency Spillway Crest: Not Applicable

(3) At Principal Spillway Crest: 1,700 feet

E. Storage Capacities:

(1) At Top of Dam: 250 acre-feet

(2) At Emergency Spillway Crest: Not Applicable

(3) At Principal Spillway Crest: 85 acre-feet

F. Reservoir Surface Areas:

(1) At Top of Dam: 56 acres

(2) At Emergency Spillway Crest: Not Applicable

(3) At Principal Spillway Crest: 15 acres

G. Dam:

(1) Type: Rolled Earth

(2) Length at Crest: 1,230 feet

(3) Height: 26 feet

(4) Top Width: 11 feet

(5) Side Slopes: Upstream 1V on 1.8H; Downstream 1V on 2.1H

(6) Zoning: Apparently Homogeneous

(7) Impervious Core: Unknown

(8) Cutoff: Unknown

(9) Grout Curtain: Unknown

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: Station 3 + 44

(2) Type: Concrete Inlet Structure with Concrete Arch Culvert Outlet

(3) Upstream Channel: Not Applicable

(4) Downstream Channel: Grass Covered, Earth Channel with moderate side slopes

I.2 Emergency Spillway:

(1) Location: None

(2) Type: Not Applicable

J. Regulating Outlets:

The only regulating outlet associated with this dam is the 8 inch diameter pipe, through the concrete inlet structure, with bolted cover plate. The invert of the pipe is 10.7 feet below the spillway crest.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

No engineering data are known to exist for this dam. To our knowledge, no construction inspection records or documented maintenance and operation data exist.

A. Surveys:

No detailed surveys have been made of the dam to our knowledge. The top of the concrete inlet structure was used as datum for our survey. The mean sea level elevation of 856.0 as obtained from the Windsor, Missouri 7.5 minute quad sheet, was used as normal pool elevation.

B. Geology and Subsurface Materials:

The site is located in the Western Plains geologic region of Missouri. The Western Plains region is characterized topographically by being level to gently undulating with wide imperceptibly rising floodplains. The sedimentary rock layers exposed in the Ozarks region dip downward away from the Ozarks region and the higher and younger sedimentary deposits become the surface ledges in southwest Missouri. Generally the soils in the Western Plains region are residual from limestone, shale and sandstone with some loess cover in some areas. Pennsylvanian sandstone and shale above the Mississippian formations formed the parent material for the soils found in the area of the dam.

Sands in the area of the dam appear to be primarily fine, sandy, silty clays with some sandstone fragments. The soils are of the Parsons - Dennis - Bates soil association. The loessial thickness map (Sheet 2 of Appendix B) indicates that some areas of this region may have between 2.5 and 5.0 feet of loess cover.

The "Geologic Map of Missouri" indicates that the nearest known fault runs in a northwest-southeasterly direction approximaterly 30 miles southwest of the dam site. 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 publication "Caves of Missouri" indicates that there are no known caves in Pettis County.

C. Foundation and Embankment Design:

No design computations are 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 measurement of spillway dimensions, embankment elevations, and a check of the drainage area on U.S.G.S. quad sheets, hydrologic analyses using U. S. Army Corps of Engineer guidelines were performed and appear in Appendix C.

E. Structure:

There are no design calculations or plans for the concrete inlet structure and the concrete arch culvert.

2.2 CONSTRUCTION:

No construction inspection data have been obtained.

2.3 OPERATION:

Normal flows are passed by the concrete inlet structure to the concrete arch culvert. No operating facilities exist.

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 INSPECTON

3.1 FINDINGS:

A. General:

The field inspection was made on July 16, 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:

Steven L. Brady, P.E. - Anderson Engineering, Inc. (Civil Engineer)
Tom Beckley, P.E. - Anderson Engineering, Inc. (Civil Engineer)
Brad Parrish, E.I.T. - Anderson Engineering, Inc. (Geotechnical Engr.)
Jack Healy, P.E. - Hanson Engineers, Inc. (Geotechnical Engineer)
Gene Wertepny, P.E. - Hanson Engineers, Inc. (Hydraulic Engineer)

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

B. Dam:

The embankment appears to be in fair condition. The horizontal alignment of the embankment is good. The vertical alignment was erratic. Numerous humps and sags were noted along the length of the dam. No apparent seepage was noted through the embankment.

The upstream and downstream slopes of the dam were heavily covered with trees and brush. Considerable erosion and sloughing of the upstream face were observed. No wave protection of the slope was noted. The roots of the trees on the upstream slope appear to be providing limited protection against erosion and sloughing. Removal of the trees without utilization of wave protection devices could result in serious loss of embankment stability.

Some minor surface cracking was observed along the crest of the embankment. No animal burrows were observed, although the thick growth of brush and trees precluded a thorough inspection of all areas of the embankment. An erosion channel of the downstream slope of the embankment at the spillway was noted. This channel was encroaching on the crest of dam. Continued unchecked erosion will result in an erosion channel through the embankment, possibly resulting in lowering the normal pool elevation and seriously affecting the stability of the embankment and spillway structure.

The vertical alignment of the embankment constructed at the easterly end of the lake was also erratic with noticeable elevation differences along the length of embankment. The pipe installed through the embankment appeared to be blocked at the inlet in the small pond to the east. The end of the pipe was not visible due to sedimentation over the pipe. Neither Mr. Oakes nor Mr. May were aware of the purpose or function of the pipe.

Shallow auger probes into the embankment indicate the dam to consist of a pale brown silty clay loam (CL.)

No instrumentation (monuments, piezometer, etc.) was observed.

C. Appurtenant Structures:

C.1 Principal Spillway:

The concrete inlet structure and arch culvert appear to be in good condition. Some surface spalling of the concrete was noted. No serious deterioration of the concrete inlet structure was observed. Minor leakage through an apparent construction joint of the arch culvert was noted (see Photograph No. 13). No measurable flow was observed. A trash fence was provided around the inlet of the structure. The fence was secured by the integral concrete post and steel post around the perimeter. One of the concrete posts failed and had not been replaced. No leakage was noted around the drawdown pipe on the cover. Mr. Oakes did not recall the drawdown pipe ever being used to lower the lake level. To his knowledge the cover plate has not been removed.

C.2 Emergency Spillway:

There is no emergency spillway associated with this dam.

D. Reservoir:

The watershed is generally grass covered with mild slopes. Sedimentation of the reservoir appears to be significant. Mr. May stated that the maximum lake depth was determined to be about 20 feet in 1976. He stated that the majority of the reservoir was very shallow. Flow into the reservoir from the northwest causes frequent overtopping of the roadway surface adjacent to the upper reach of the lake. A submerged concrete culvert, approximately 8 feet high and 10 feet wide, was noted under the railroad fill along the east side of the reservoir. The flow line of the culvert appeared to be about 10 feet below normal pool elevation of the lake. No serious erosion or sloughing of the reservoir areas was noted.

E. Downstream Channel:

The immediate downstream channel is well defined with some large trees noted on the side slopes. Erosion around the trees on the slopes was observed. The downstream channel is generally grass covered and wooded with mild side slopes.

3.2 EVALUATION:

The trees and brush growth on the dam can provide shelter for small animals and encourage burrowing. Additionally the trees are potential seepage hazards. The erosion, surface cracking, and sloughing of the embankment could worsen and affect the stability of the embankment. The trees in the downstream spillway channel could restrict flood flows. The leakage through the arch culvert could worsen and lead to loss of structural stability.

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

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, and the capacity of the uncontrolled concrete inlet structure.

4.2 MAINTENANCE OF DAM:

Information obtained from Mr. Oakes and Mr. May indicates that no regular maintenance program has been established. Maintenance is performed on the dam on an as needed basis.

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 surface cracking along the crest of the dam, the leakage through the concrete arch culvert, the sloughing of the upstream slope, the erosion of the upstream slope and embankment, the thick growth of trees and brush on the embankment and downstream channel, and the vertical alignment of the crest are deficiencies which should be corrected. Remedial measures should be investigated by an engineer experienced in the design and construction of dams. Subsequently, these areas should be inspected periodically to detect any further erosion or sloughing.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. Design Data:

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

B. Experience Data:

No recorded rainfall, runoff, discharge, or reservoir stage data were available for this lake and watershed. Information received from Mr. Oakes indicated that the high water level was about 30 inches above the spillway flowline (Elevation 858.5). Our hydrologic and hydraulic analyses using U. S. Army Corps of Engineers guidelines appear in Appendix C.

C. Visual Observations:

The approach to the concrete inlet structure is clear. A trash fence is provided around the inlet. The concrete arch culvert carries flow to beyond the toe of the embankment, and spillway releases would not be expected to endanger the dam. The immediate downstream channel is well defined and appears to be non-erodible.

D. Overtopping Potential:

The hydraulic and hydrologic analyses (using the U. S. Army Corps of Engineers guidelines and the HEC-1 computer program) were based on: (1) a field survey of spillway dimensions and embankment elevations; and (2) an estimate of the reservoir storage and the pool and drainage areas from the Windsor, Missouri 7.5 minute U.S.G.S. quad sheet.

Based on the hydrologic and hydraulic analyses presented in Appendix C, the spillway will pass 32 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 (small size with high downstream hazard potential) pass 50 percent to 100 percent of the PMF, without overtopping. Considering the height of dam (26 feet) and the maximum storage capacity (250 acre-feet), 50 percent of the PMF has been determined to be the appropriate spillway design flood. The spillway will pass a 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 7,776 cfs. For 50 percent of the PMF, the peak inflow was 3,888 cfs.

The routing of the PMF through the spillways and dam indicates that the dam will be overtopped by 2.2 ft at elevation 862.7. The duration of the overtopping will be 5.0 hours, and the maximum outflow will be 7,241 cfs. The maximum discharge capacity of the spillway, at elevation 860.5, is 1,670 cfs. The routing of 50 percent of the PMF indicates that the dam will be overtopped by 1.0 ft at elevation 861.5. The maximum outflow will be 2,880 cfs, and the duration of overtopping will be 2.3 hours. 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:

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 reported post-construction changes include the dredging of the lake, construction of the "fingers" extending into the reservoir, and the construction of the embankment near the east end of the lake forming the triangular pond.

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.

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 fair condition. Several items were noted during the visual inspection which should be investigated further, corrected or controlled. These items are: (1) minor surface cracking in the crest of the dam; (2) considerable sloughing of the upstream slope; (3) irregular vertical alignment of crest; (4) considerable erosion on the upstream slope and crest; (5) thick growth of trees and brush on embankment; (6) some large trees in the downstream channel; and (7) leakage through the concrete arch culvert.

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

The dam will be overtopped by flows in excess of 32 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 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 items recommended in paragraph 7.2A should be pursued without undue delay.

D. Necessity for Additional Inspection:

Based on the results 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.

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 50 percent of 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 surface cracking should be investigated and remedial measures performed under the guidance of an engineer experienced in the design and construction of dams.

(3) The vertical alignment of the crest of the dam should be improved.

(4) The tree and brush growth should be removed from the dam. This should be done under the guidance of a professional engineer experienced in the design and construction of dams. Indiscriminate clearing methods could jeopardize the safety of the dam.

(5) The erosion and slough areas on the upstream face and embankment should be corrected and maintained. Wave protection such as riprap will be required to prevent further erosion and sloughing.

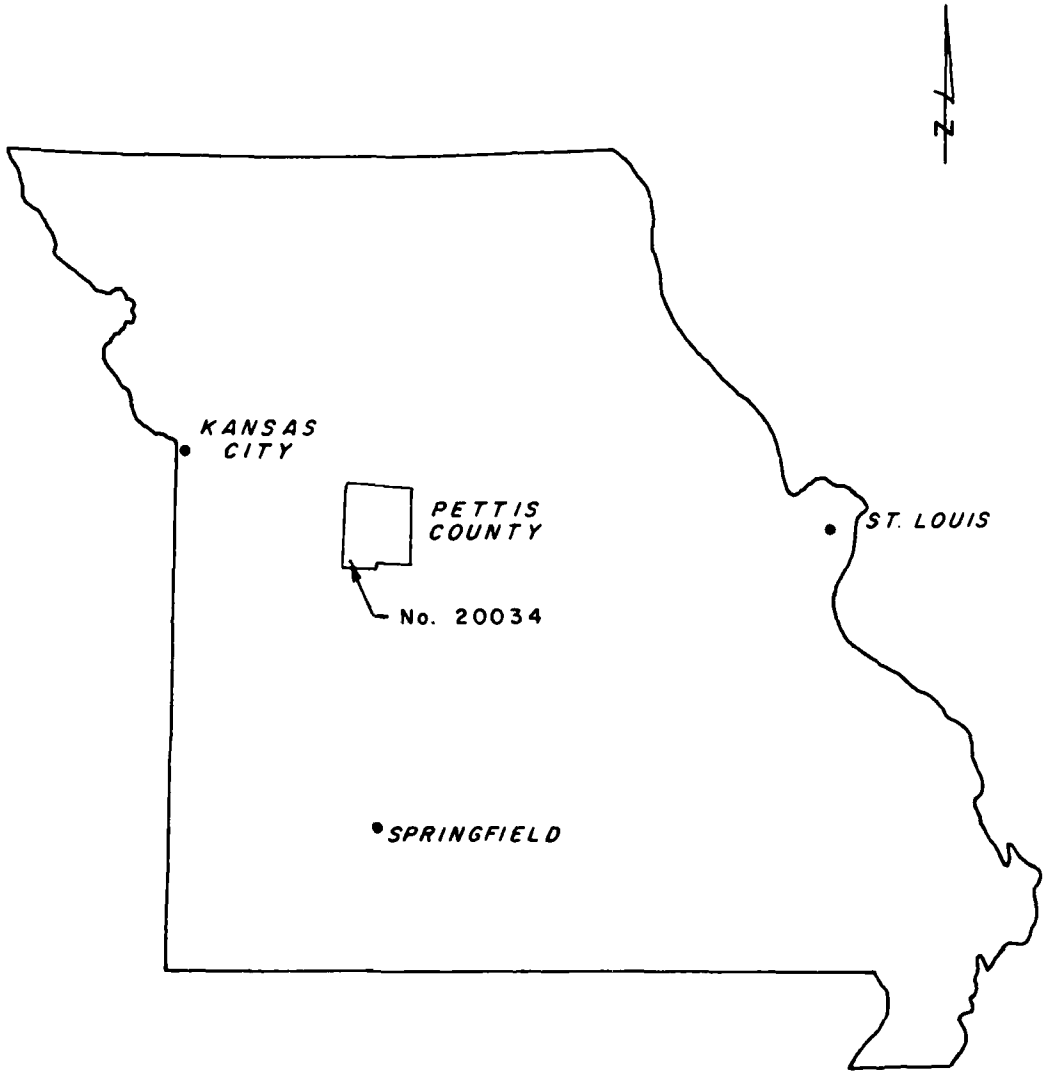
(6) The large trees should be removed from the downstream spillway channel.

(7) The leakage through the construction joint of the concrete arch culvert should be investigated by an engineer experienced in the design and construction of concrete structures. Remedial measures may be required.

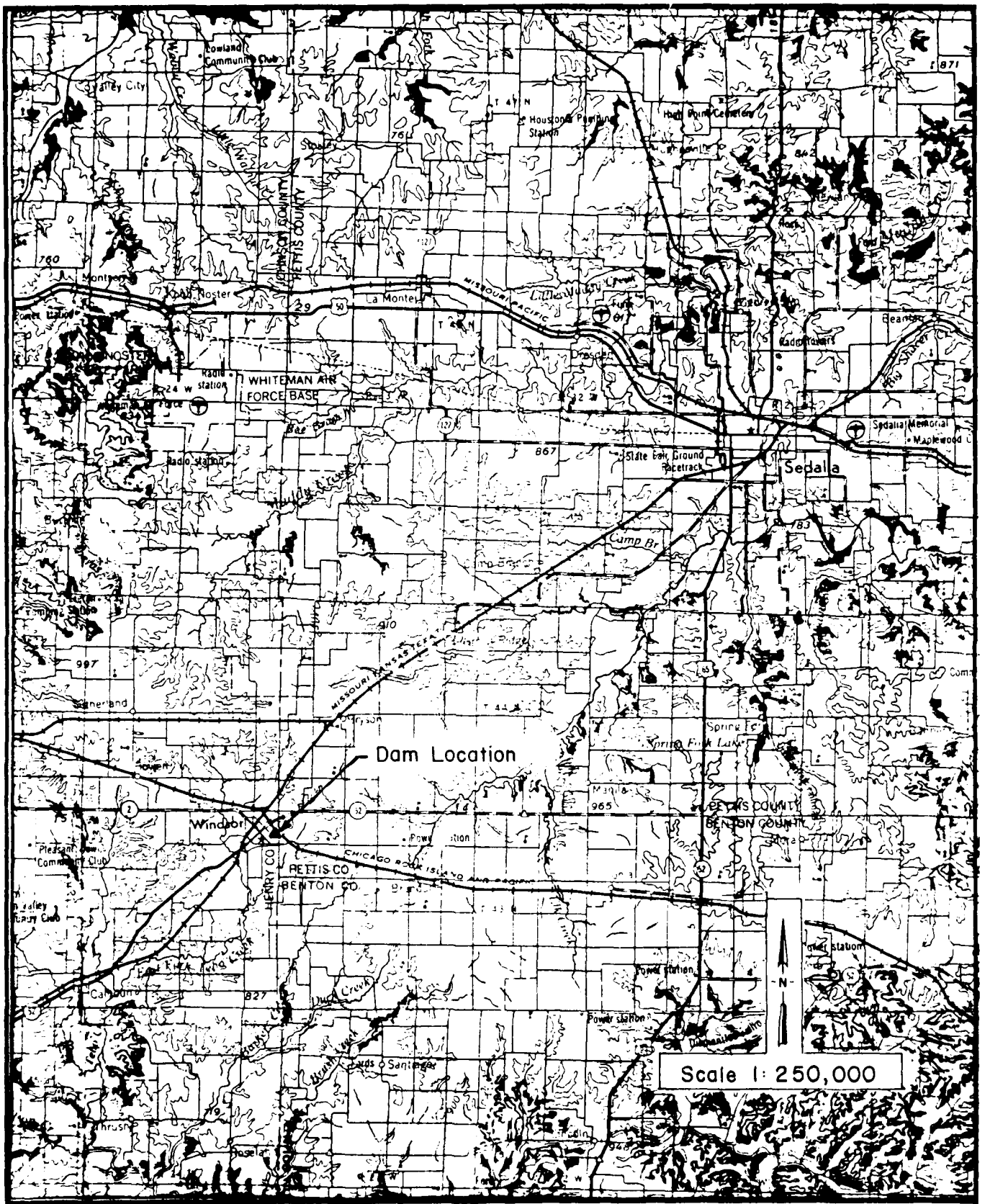
(8) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

APPENDIX A

Dam Location and Plans



LOCATION MAP



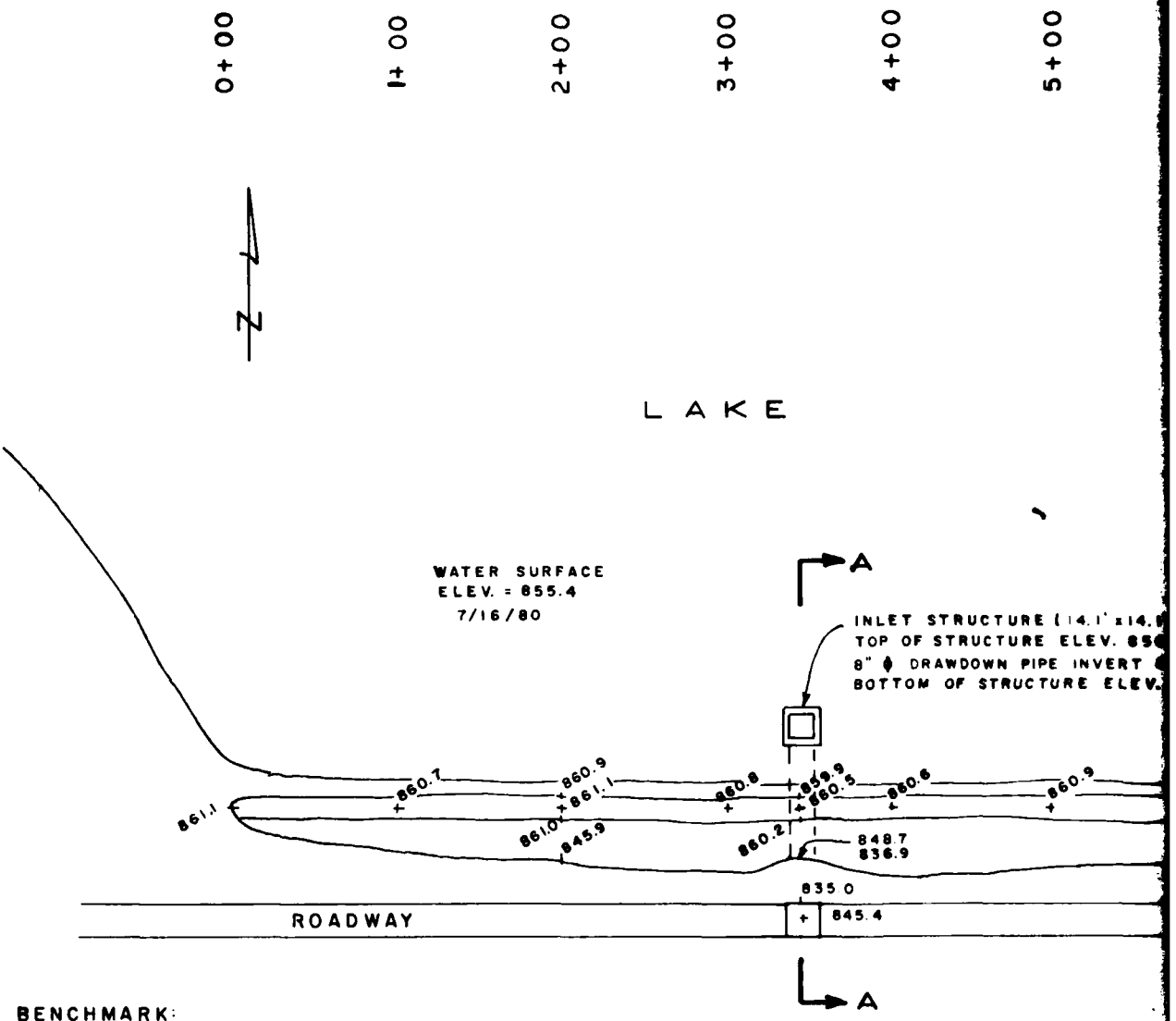
VICINITY MAP

HANSON ENGINEERS
INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

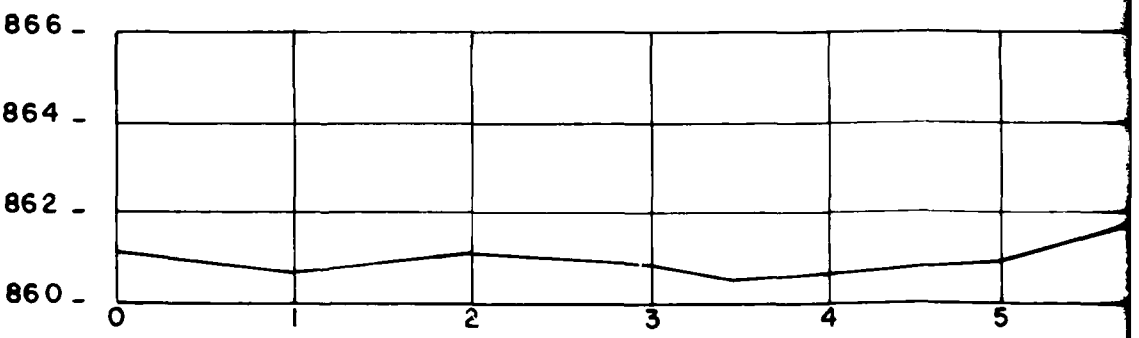
Windsor Farrington Park Lake Dam
Pettis County, Missouri
Mo. I.D. No. 20034

Sheet 2, Appendix A

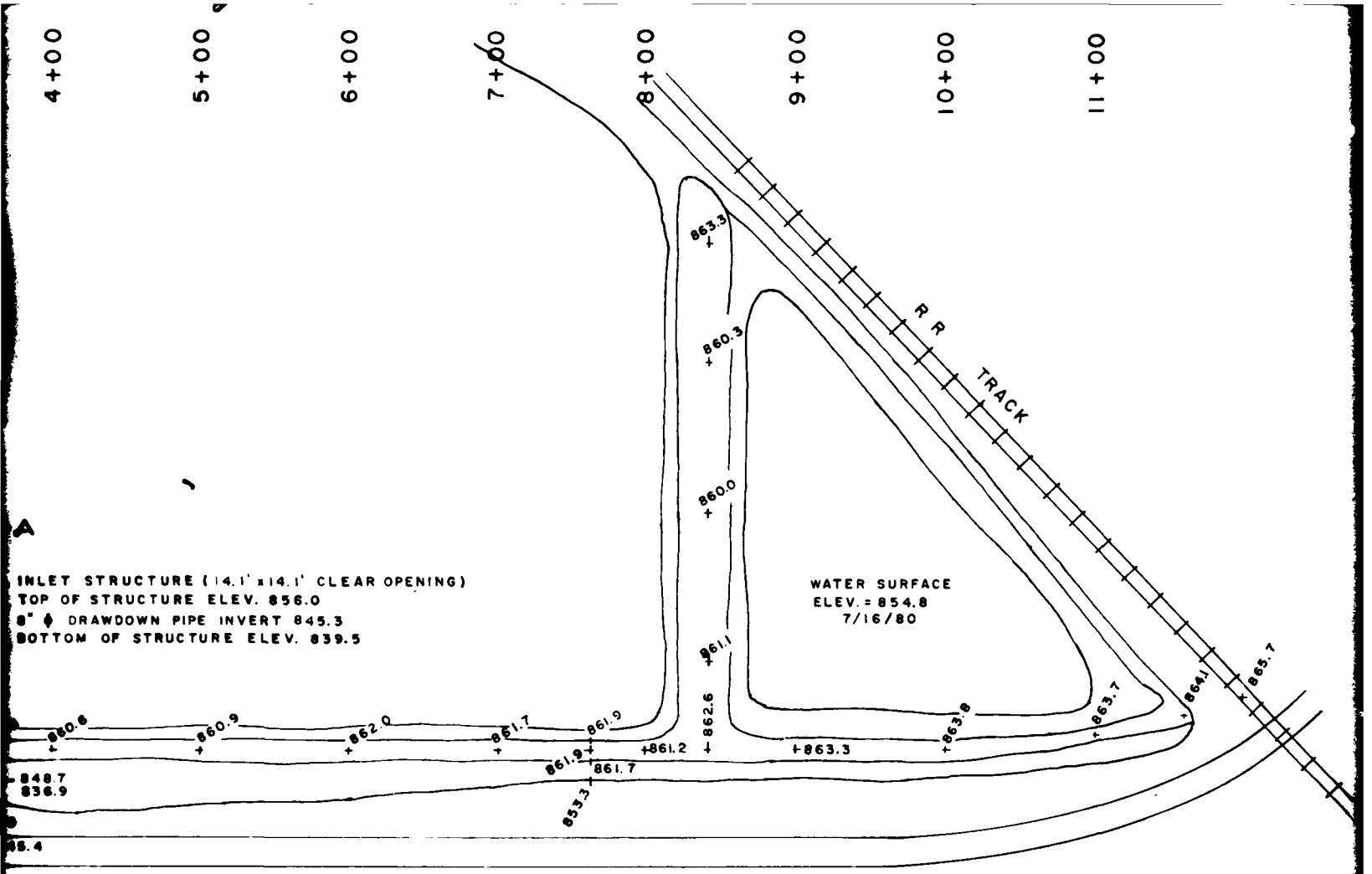


BENCHMARK:
SOUTHWEST CORNER OF TOP OF INLET STRUCTURE AT STA 3+44 29 FEET LEFT OF CENTERLINE OF DAM.
ELEV. = 856.0

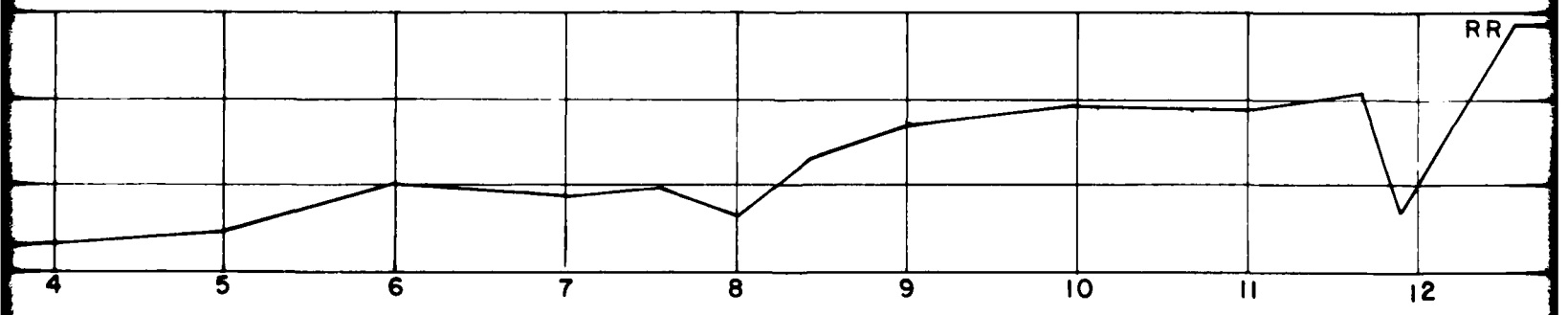
PLAN VI



PR

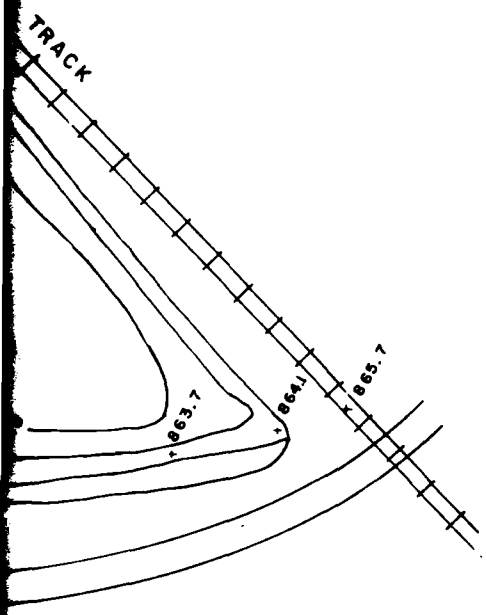


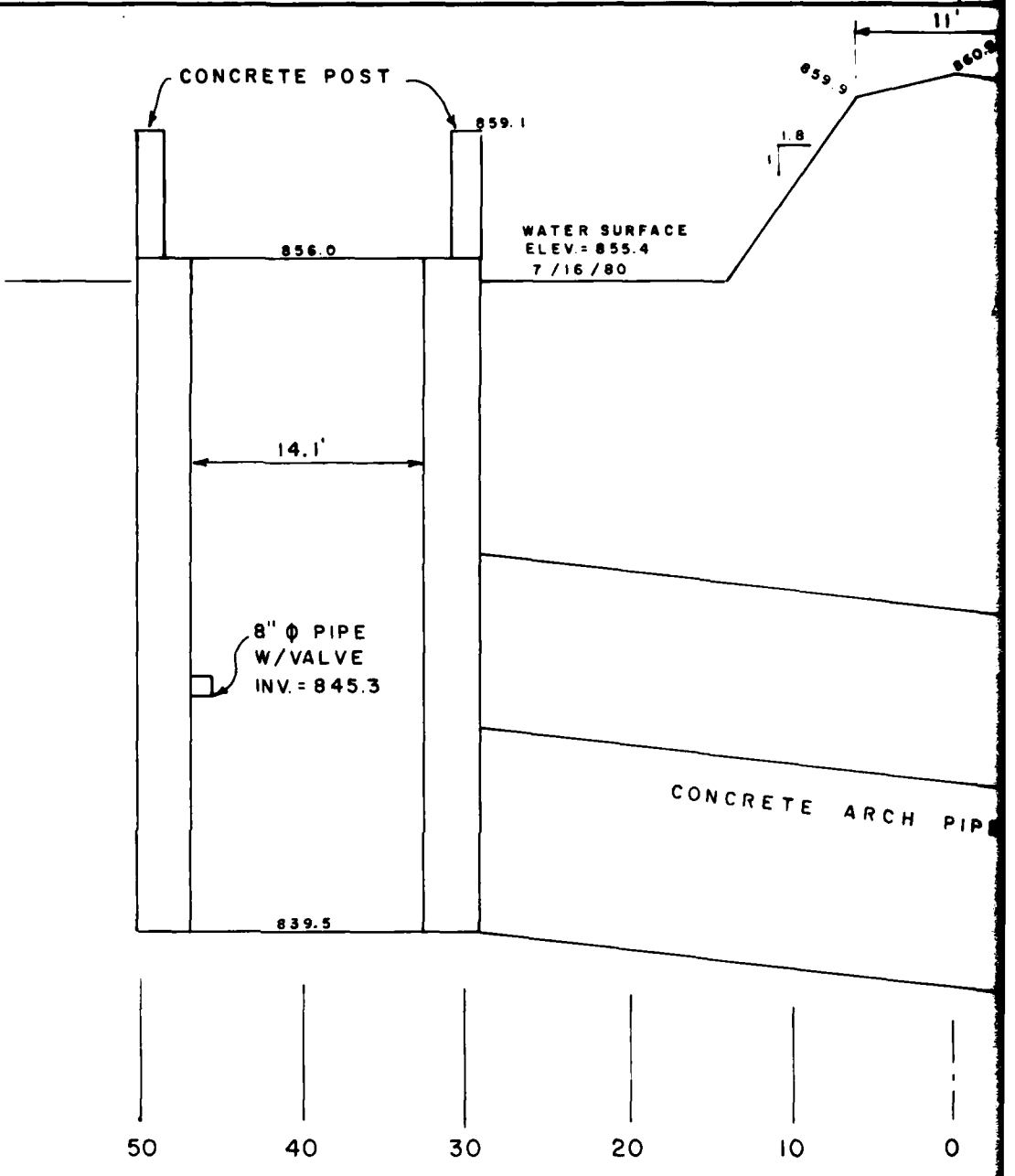
PLAN VIEW

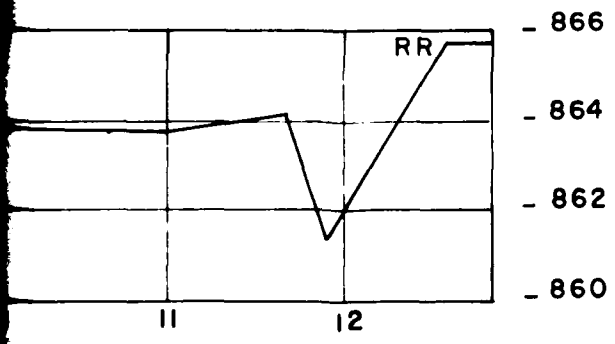


PROFILE

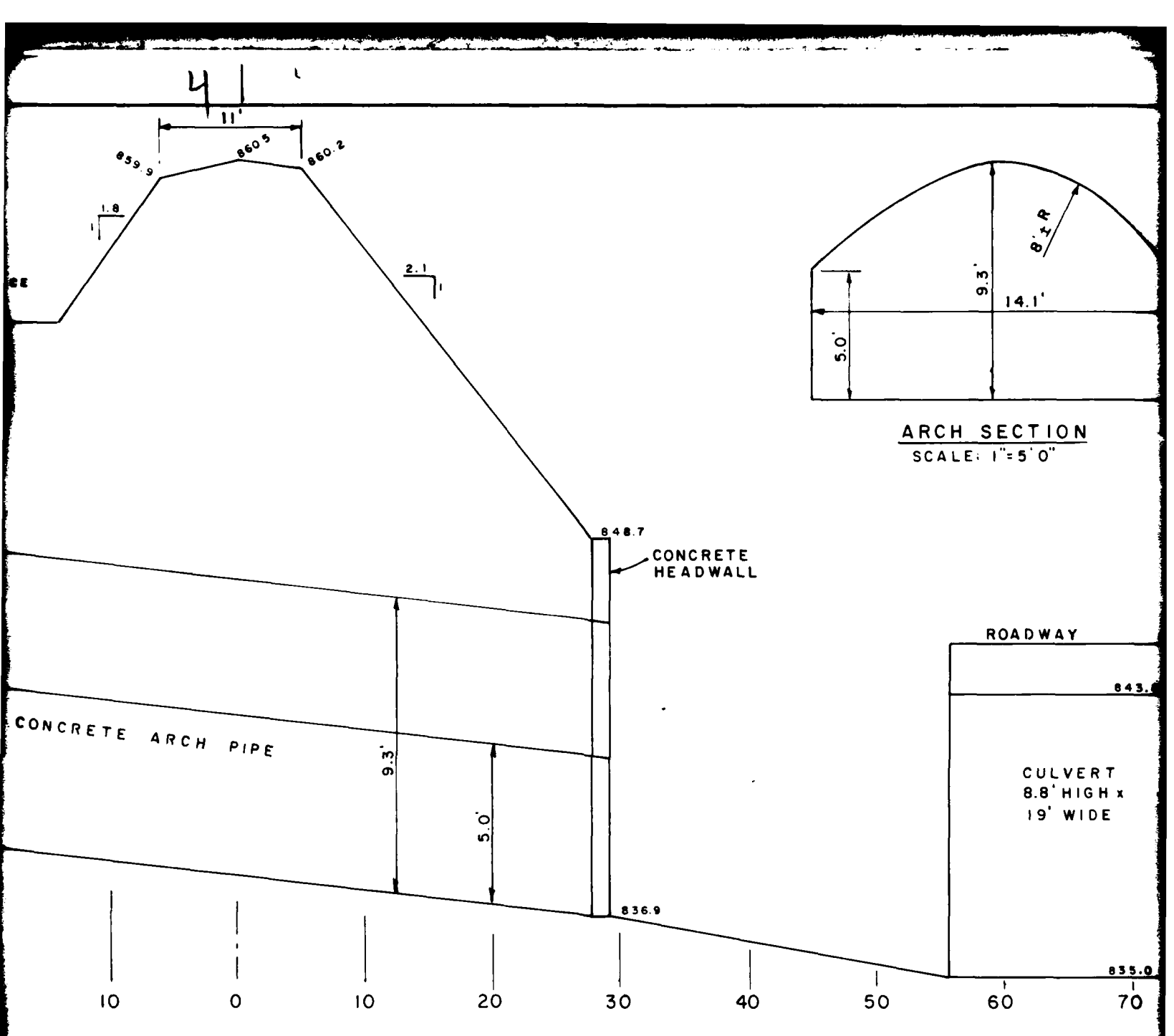
11+00


TRACK
863.7
864.1
865.7


CONCRETE POST
859.1
856.0
11'
859.9
1.8
1
WATER SURFACE
ELEV.= 855.4
7/16/80
14.1'
8" ϕ PIPE
W/VALVE
INV.= 845.3
839.5
CONCRETE ARCH PIP
50
40
30
20
10
0


RR
866
864
862
860
11
12

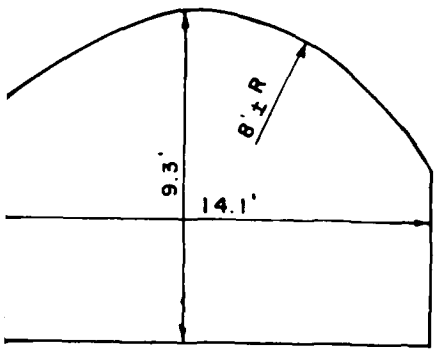
SE



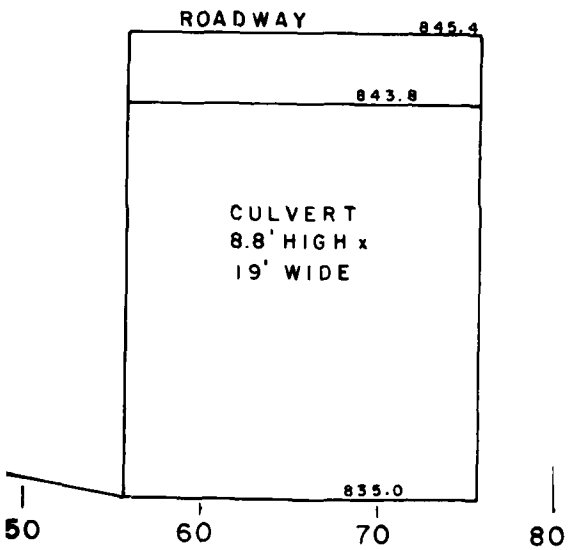
SECTION A-A STA 3+44

ARCH SECTION

SCALE: 1"=5'0"



ARCH SECTION
SCALE: 1"=5'0"



SHEET 3 APPENDIX A

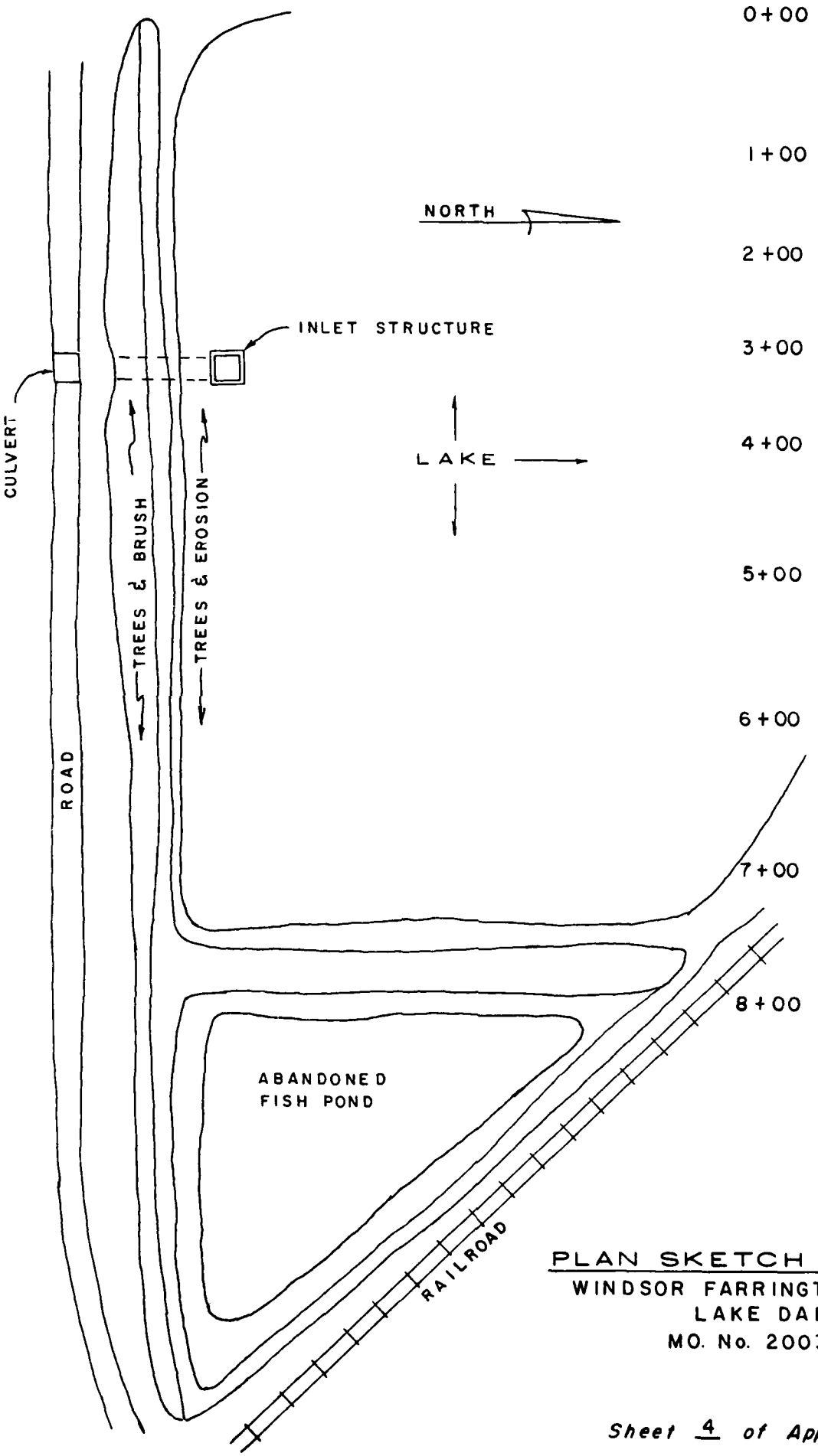
ANDERSON ENGINEERING, INC.
730 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

WINDSOR FARRINGTON
PARK LAKE DAM

MO. No. 20034

PLAN & PROFILE

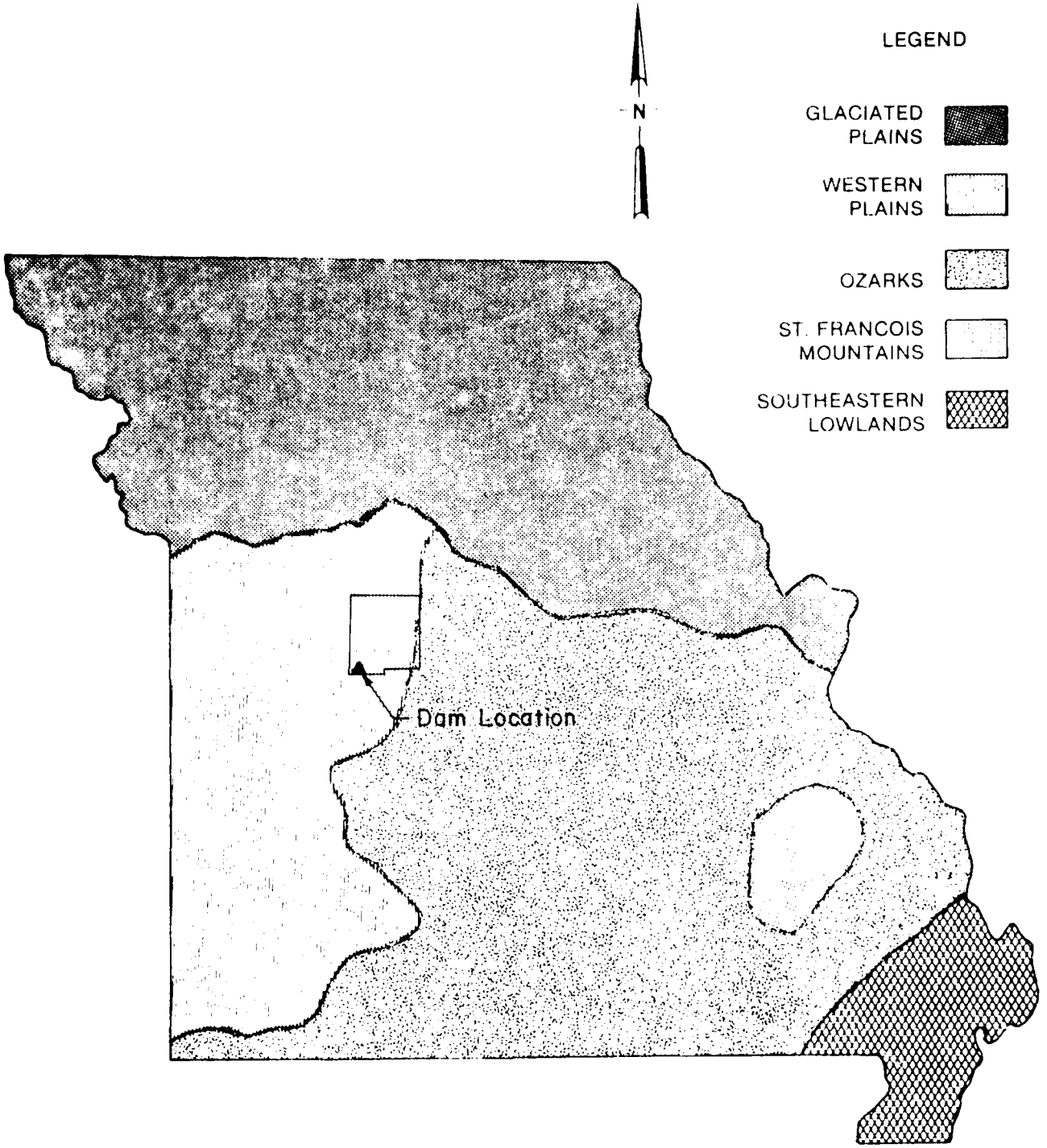
PETTIS COUNTY, MO.



PLAN SKETCH OF DAM
WINDSOR FARRINGTON PARK
LAKE DAM
MO. No. 20034

APPENDIX B

Geology and Soils



MAJOR GEOLOGIC REGIONS OF MISSOURI

HANSON ENGINEERS

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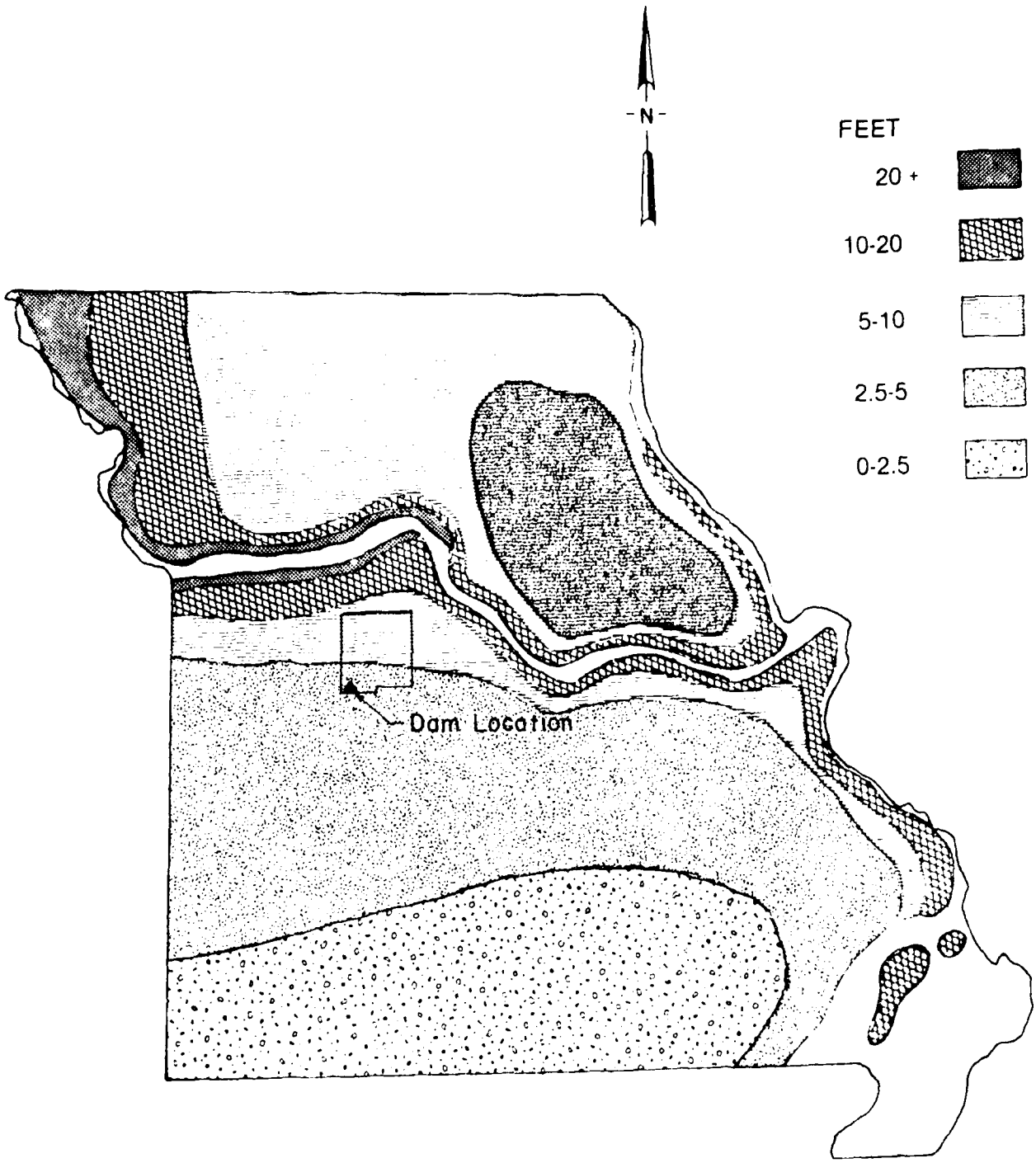
Windsor Farrington Park Lake Dam
Pettis County, Missouri
Mo. I.D. No. 20034

SHEET 1, APPENDIX B



THICKNESS OF LOESSIAL DEPOSITS

HANSON ENGINEERS INCORPORATED

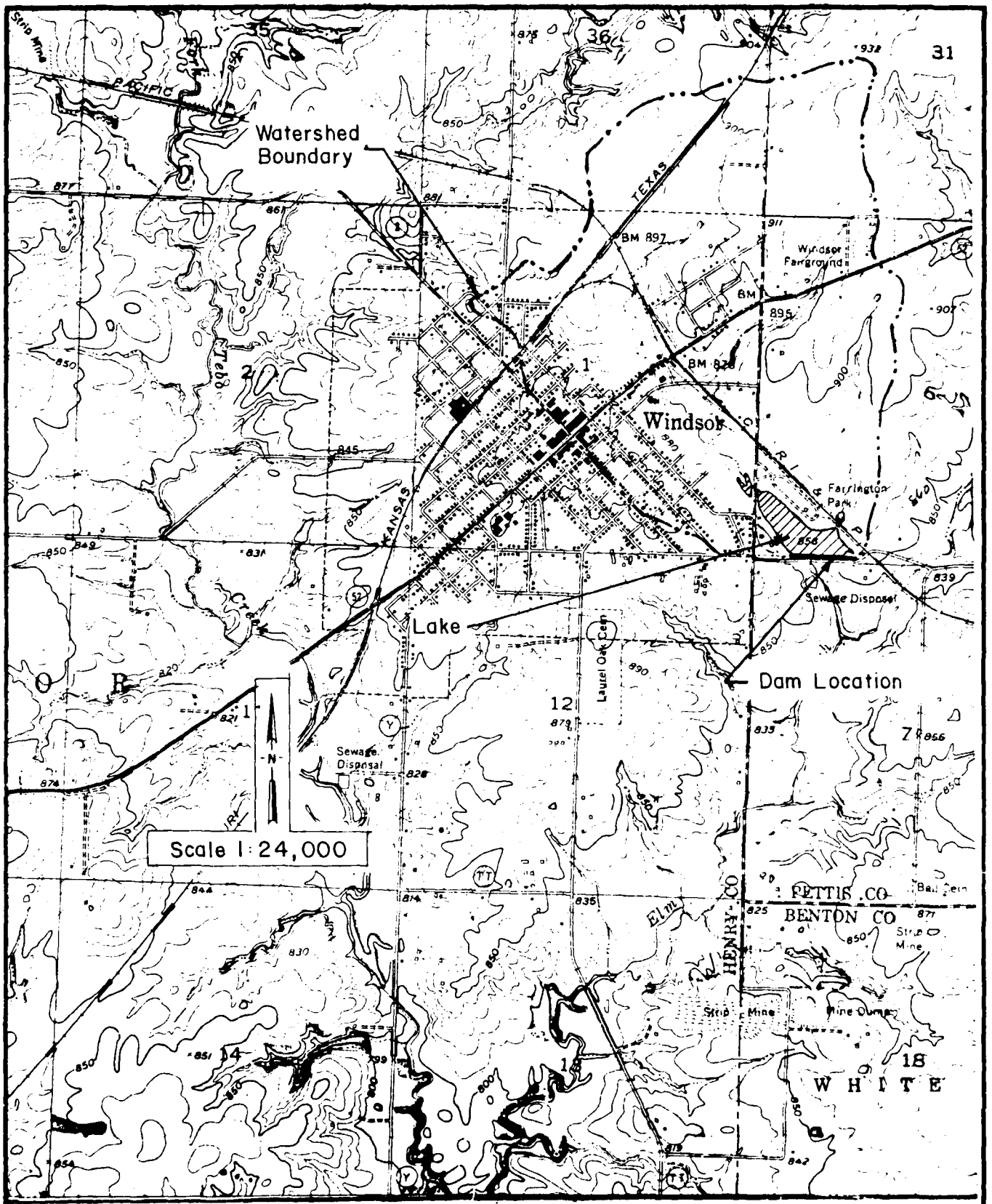
SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Windsor Farrington Park Lake Dam
Pettis County, Missouri
Mo. I.D. No. 20034

SHEET 2, APPENDIX B

APPENDIX C

Overtopping Analysis



LAKE AND WATERSHED MAP

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Windsor Farrington Park Lake Dam
Pettis County, Missouri
Mo. I.D. No. 20034

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 48-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 (10 min. interval - 48 hours duration), 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 and culvert entrance control.

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 over a broad-crested weir.

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)	1.21	sq miles
Length of Watercourse (L)	1.90	miles
Difference in elevation (H)	84	ft
Time of concentration (Tc)	1.0	hrs
Lag Time (Lg)	0.6	hrs
Time to peak (Tp)	0.68	hrs
Peak Discharge (Qp)	860	cfs
Duration (D)	10	min.

Time (Min.)(*)	Discharge (cfs)(*)
0	0
10	120
20	386
30	733
40	855
50	785
60	614
70	390
80	261
90	179
100	119
110	81
120	54
130	36
140	24
150	16
160	11
170	8
180	5

(*) From the computer output

FORMULA USED:

$$Tc = \left(\frac{11.9\ L^3}{H} \right)^{0.385}$$ From California Culverts Practice, California Highways and Public Works, September, 1942.

$$Lg = 0.6\ Tc$$

$$Tp = \frac{D}{2} + Lg$$

$$Qp = \frac{484\ A.Q}{Tp}$$ Q = Excess Runoff = 1 inch

TABLE 2

RAINFALL-RUNOFF VALUES

Selected Storm Event	Storm Duration (Hours)	Rainfall (Inches)	Runoff (Inches)	Loss (Inches)
PMP	48	32.89	31.55	1.34
1% Prob. Flood	48	9.08	6.48	2.60

Additional Data:

1) Soil Conservation Service Soil Group C
2) Soil Conservation Service Runoff Curve CN = 88 (AMC III) for the PMF
3) Soil Conservation Service Runoff Curve CN = 75 (AMC II) for the 1 percent chance flood
4) Percentage of Drainage Basin Impervious 15 percent

TABLE 3

ELEVATION, SURFACE AREA, STORAGE AND DISCHARGE RELATIONSHIPS

Elevation (feet-MSL)	Lake Surface Area (acres)	Lake Storage (acre-ft)	Spillway Discharge (cfs)
839.0	0	0	-
*856.0	15	85	0
860.0	54	223	1,320
**860.5	56	250	1,670
865.0	76	548	2,200
870.0	96	-	-

*Principal spillway crest elevation

**Top of dam elevation

The above relationships were developed using data from the USGS Windsor, MO 7.5 minute quadrangle map, and the field measurements.

TABLE 4

SPILLWAY RATING CURVE

Reservoir Elevation (MSL)	Principal Spillway (cfs)
856.0	0 (Wier Flow)
857.0	150 (Wier Flow)
858.0	430 (Wier Flow)
858.5	620 (Wier Flow)
859.1	870 (Wier Flow)
860.0	1,320 (Wier Flow)
*860.5	1,670 (Pipe Flow)
861.0	1,960 (Pipe Flow)
862.0	2,020 (Pipe Flow)
863.0	2,080 (Pipe Flow)
864.0	2,140 (Pipe Flow)

*Top of dam elevation

METHOD USED: Assuming weir control over a broad-crested weir, and culvert entrance control.

a) Weir Control

Formula: $Q = CLH^{1.5}$

Q = Discharge in cfs.
C = Discharge coefficient from Table 5-3 page 5-46 (Handbook of Hydraulics by King-Brater). C varies from 2.26 to 3.32
L = Effective length of weir in ft.
H = Effective head above the weir crest in ft.

b) Culvert Entrance Control

Using charts from the U. S. Bureau of Public Roads

TABLE 5

RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (cfs)	Peak Lake Elevation (ft, MSL)	Total Storage (acre-ft)	Peak Outflow (cfs)	Depth (ft) Over Top of Dam
-	0	*856.0	85	0	-
0.10	778	858.0	154	432	-
0.20	1,555	859.4	202	1,015	-
0.25	1,944	860.0	223	1,313	-
0.30	2,333	860.4	243	1,578	-
0.32	2,488	**860.5	250	1,670	0
0.35	2,722	860.7	264	1,810	0.2
0.40	3,110	861.0	284	2,127	0.5
0.50	3,888	861.5	315	2,880	1.0
0.75	5,832	862.2	365	5,123	1.7
1.00	7,776	862.7	397	7,241	2.2

The percentage of the PMF that will reach the top of the dam is 32 percent.

*Principal spillway crest elevation

**Top of dam elevation

```
A       OVERTOPPING ANALYSIS FOR WINDSOR FARRINGTON PARK LAKE DAM ( # 15 )
A       STATE ID NO. 20034  COUNTY NAME : PETTIS
A       HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 80S3001
B    288                10
B1     5
J      1        9        1
J1   .10      .20      .25      .30      .35      .40      .50      .75      1.0
K      0        1                                  3        1
K1      INFLOW HYDROGRAPH COMPUTATION **
M      1        2     1.21               1.21        1                          1
P      0     25.3      102      120      130
T                                                                -1      -88             0.15
W2  1.00     0.60
X      0     -.1         2
K      1        2                        0        4        1
K1      RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE **
Y                                     1        1
Y1     1                                                        85       -1
Y4   856      857      858    859.1      860    860.5      861      862      863      864
Y5     0      150      430      870     1320     1670     1960     2020     2080     2140
$S     0       85      223      250      548
$E   839      856      860    860.5      865
$$   856
$D 860.5
$L     0       70      120       20      520      620      825      850      980     1180
$V 860.5    860.6    860.7    860.8    861.1    861.7      862    862.6    863.7    864.1
K     99
```

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

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	RATIO 9
				0.10	0.20	0.25	0.30	0.35	0.40	0.50	0.75	1.00
HYDROGRAPH AT	1	1.21	1	778.	1555.	1944.	2333.	2722.	3110.	3888.	5832.	7776.
	(	3.13)	(	22.02)(	44.04)(	55.05)(	66.06)(	77.07)(	88.08)(	110.10)(	165.15)(	220.20)
ROUTED TO	2	1.21	1	432.	1015.	1313.	1578.	1810.	2127.	2880.	5123.	7241.
	(	3.13)	(	12.24)(	28.74)(	37.18)(	44.70)(	51.24)(	60.23)(	81.55)(	145.08)(	205.06)

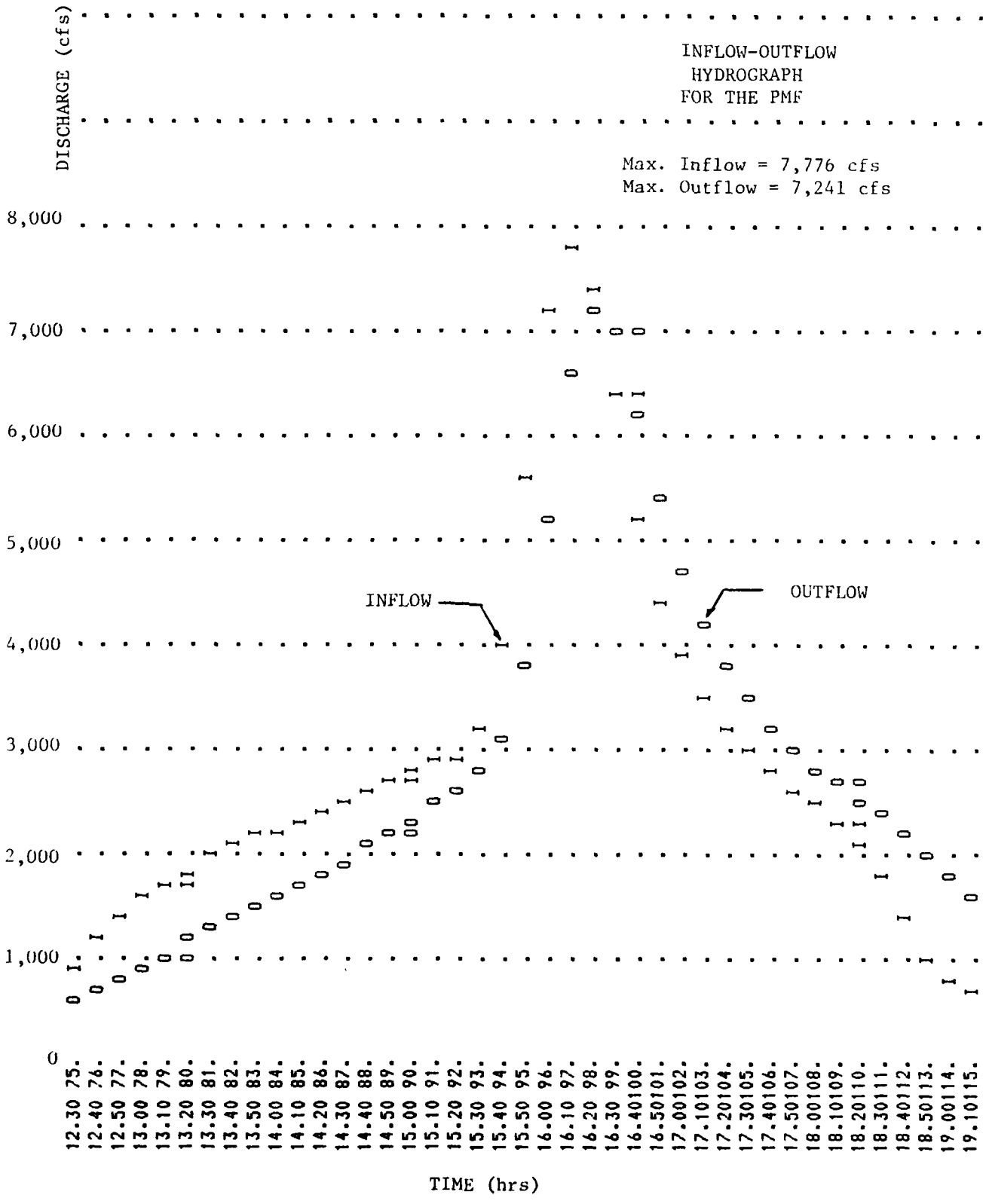
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	856.00	856.00	860.50
STORAGE	85.	85.	250.
OUTFLOW	0.	0.	1670.

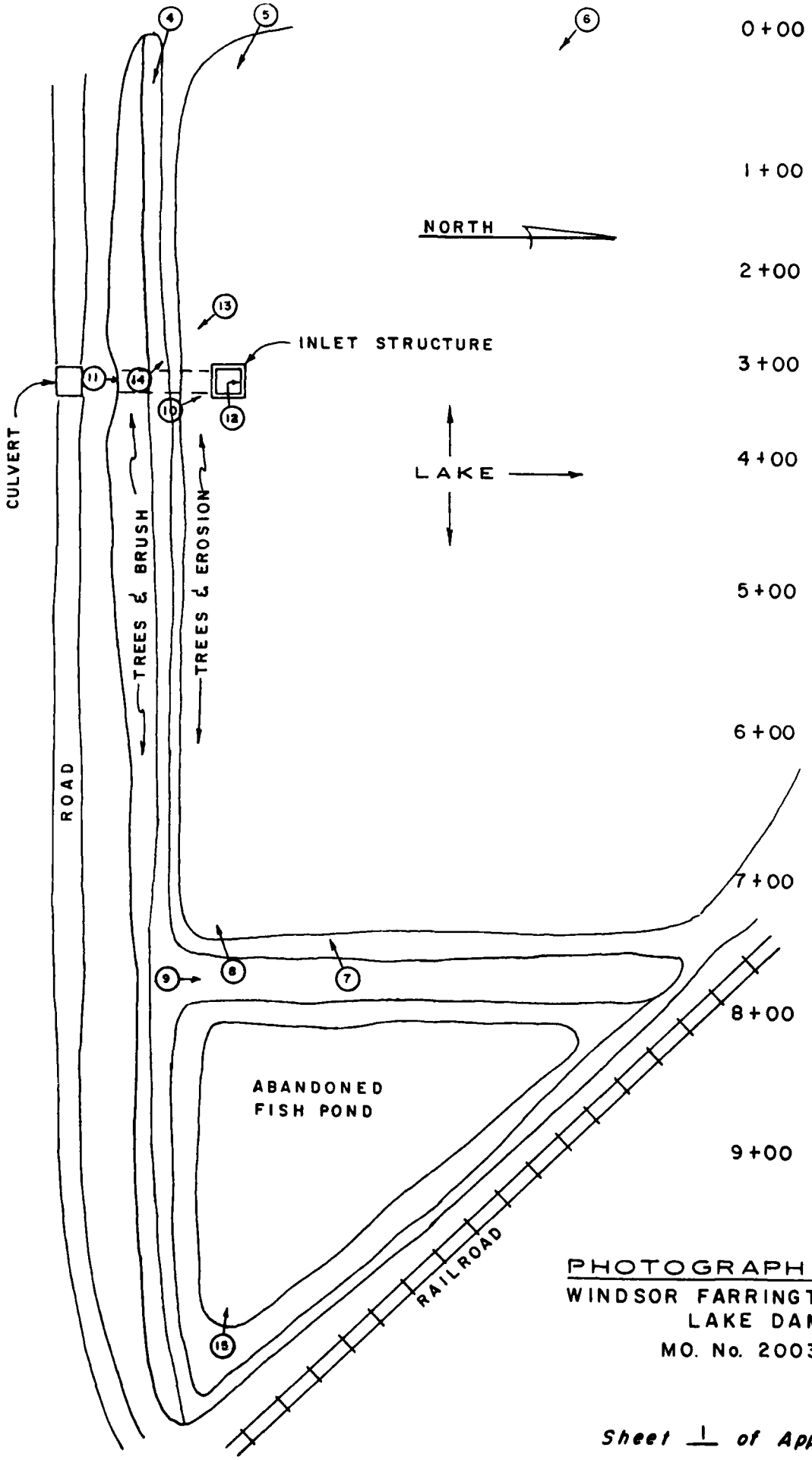
PMF RATIOS OUTPUT DATA

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	858.01	0.00	154.	432.	0.00	16.83	0.00
0.20	859.39	0.00	202.	1015.	0.00	16.67	0.00
0.25	859.99	0.00	223.	1313.	0.00	16.67	0.00
0.30	860.37	0.00	243.	1578.	0.00	16.67	0.00
0.35	860.71	0.21	264.	1810.	1.00	16.67	0.00
0.40	861.01	0.51	284.	2127.	1.50	16.67	0.00
0.50	861.49	0.99	315.	2880.	2.33	16.67	0.00
0.75	862.24	1.74	365.	5123.	4.00	16.50	0.00
1.00	862.72	2.22	397.	7241.	5.00	16.33	0.00


DISCHARGE (cfs)
INFLOW-OUTFLOW
HYDROGRAPH
FOR THE PMF
Max. Inflow = 7,776 cfs
Max. Outflow = 7,241 cfs
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
INFLOW
OUTFLOW
12.30 75.
12.40 76.
12.50 77.
13.00 78.
13.10 79.
13.20 80.
13.30 81.
13.40 82.
13.50 83.
14.00 84.
14.10 85.
14.20 86.
14.30 87.
14.40 88.
14.50 89.
15.00 90.
15.10 91.
15.20 92.
15.30 93.
15.40 94.
15.50 95.
16.00 96.
16.10 97.
16.20 98.
16.30 99.
16.40100.
16.50101.
17.00102.
17.10103.
17.20104.
17.30105.
17.40106.
17.50107.
18.00108.
18.10109.
18.20110.
18.30111.
18.40112.
18.50113.
19.00114.
19.10115.
TIME (hrs)

APPENDIX D

Photographs



PHOTOGRAPH INDEX

WINDSOR FARRINGTON PARK
LAKE DAM
MO. No. 20034

LIST OF PHOTOGRAPHS

PHOTO NO.	DESCRIPTION
1	Aerial View of Lake and Dam
2	Aerial View of Lake and Dam
3	Aerial View of Lake and Dam
4	Crest of Embankment (Looking East)
5	Upstream Face of Embankment (Looking Southeast)
6	Upstream Face of Embankment (Looking Southeast)
7	Upstream Face of Embankment (Looking Southwest)
8	Upstream Face of Embankment (Looking Southwest)
9	Crest of Embankment (Looking North)
10	Spillway Inlet Structure (Looking North)
11	Concrete Arch Channel and Inlet Structure (Looking North)
12	Drawdown Pipe In Inlet Structure (Looking North)
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14	Downstream Spillway Channel From Arch (Looking South)
15	Adjacent Pond and Embankment (Looking Southwest)
16	Downstream Hazard Zone


1

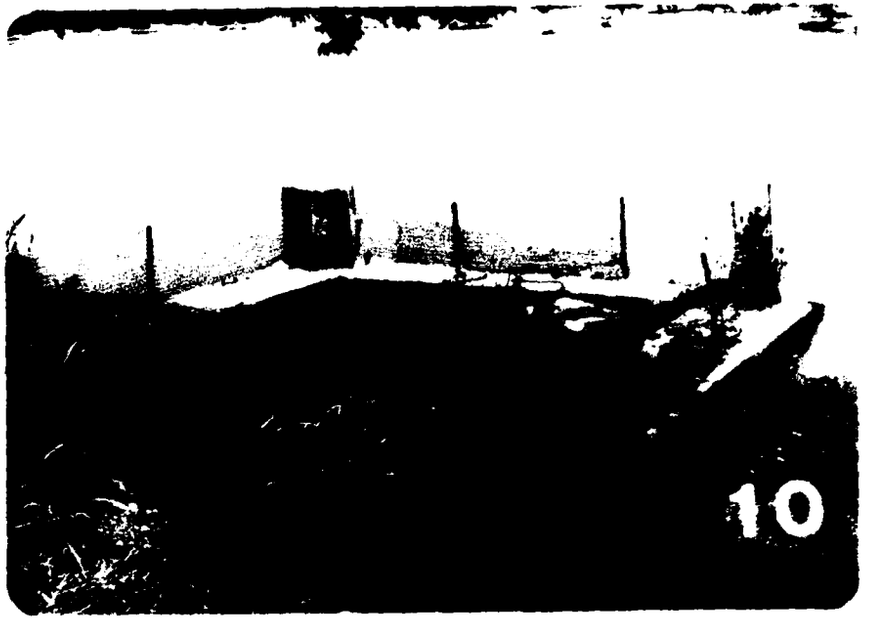

2


3


4

8


9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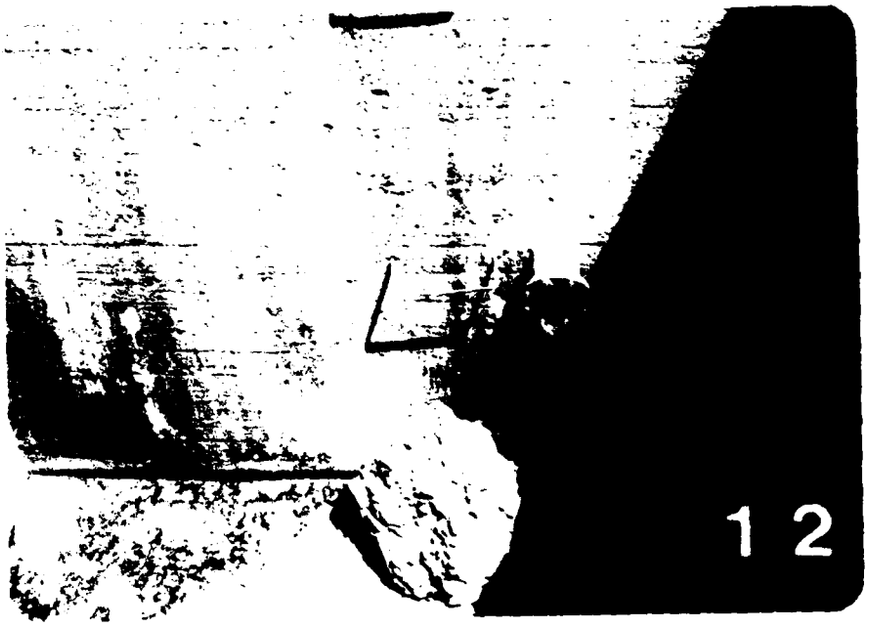
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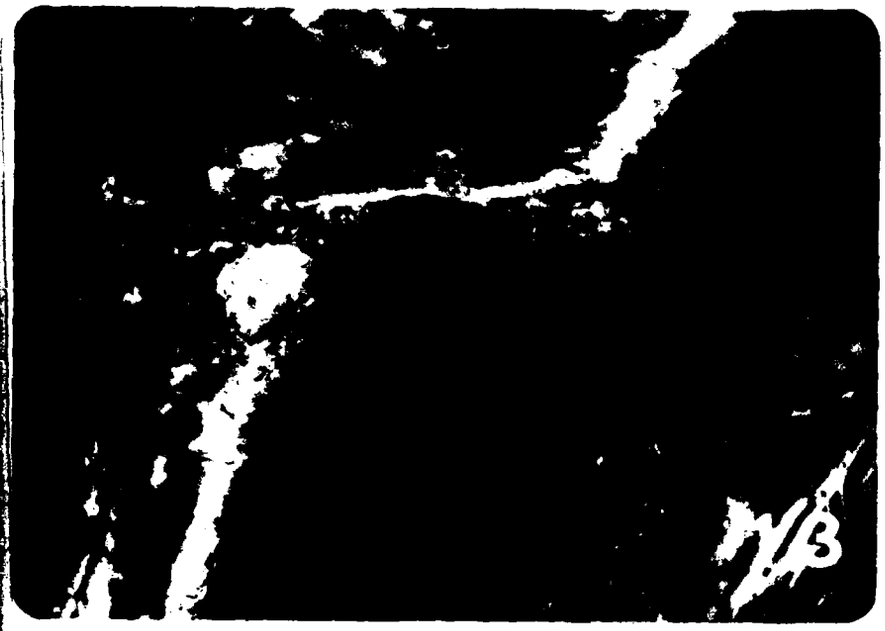


DA
FILM