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NATIONAL DAM SAFETY PROGRAM. BRAY LAKE DAM (MO 30098); OSAGE - --ETC(U)

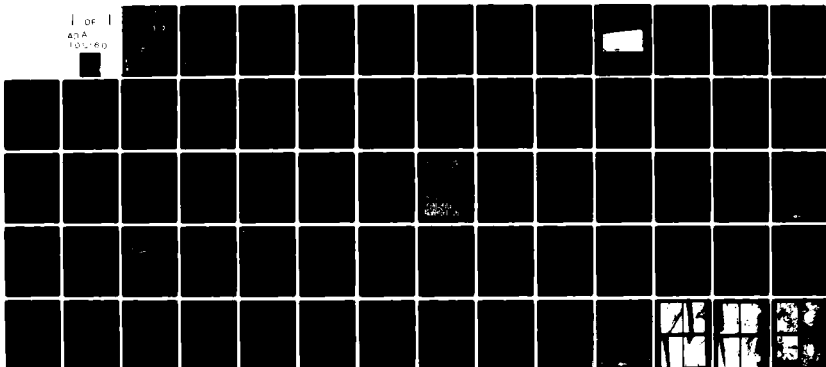
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OSAGE - GASCONADE BASIN

**BRAY LAKE DAM
PHELPS COUNTY, MISSOURI
MO 30098**

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PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM



**United States Army
Corps of Engineers**
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St. Louis District

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

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|---|-------------------------------------|---|
| 1. REPORT NUMBER | 2. GOVT ACCESSION NO. AD-4105160 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Bray Lake Dam (MO 30098) Phelps County, Missouri | | 5. TYPE OF REPORT & PERIOD COVERED Final Report |
| 7. AUTHOR(s) Anderson Engineering, Inc. Jack /Healy Steve /Brady Gene /Wertepny Tom /Beckley Dan /Kerns | | 6. PERFORMING ORG. REPORT NUMBER |
| 9. PERFORMING ORG. NAME & ADDRESS U.S. Army Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101 | | 8. CONTRACT OR GRANT NUMBER(s) DACW43-79-C-00701 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 14611 |
| 13. MONITORING NAME & ADDRESS (if different from Controlling Office) National Dam Safety Program. Bray Lake Dam (MO 30098), Osage - Gasconade Basin, Phelps County, Missouri. Phase I Inspection Report. | | 12. REPORT DATE December 1979 |
| 16. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) Approved for release; distribution unlimited. | | 13. NUMBER OF PAGES Approximately 60 |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) | | 15. SECURITY CLASS. (of this report) UNCLASSIFIED |
| 18. SUPPLEMENTARY NOTES | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams | | |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property. | | |

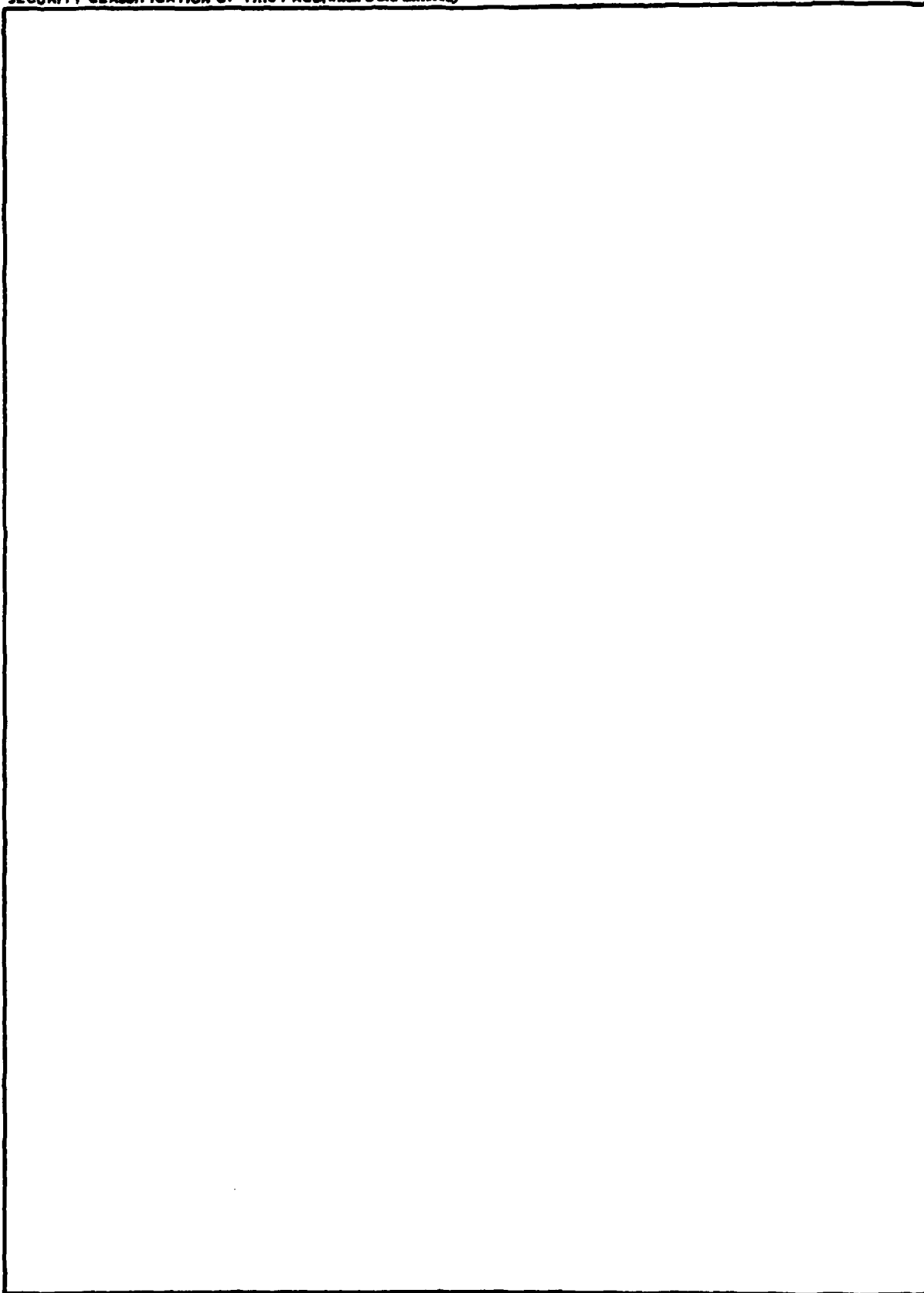
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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Bray Lake Dam (MO 30098)

This report presents the results of field inspection and evaluation of the Bray Lake Dam. It was prepared under the National Program of Inspection of Non-Federal Dams. The inspection of Bray Lake Dam revealed serious seepage on the downstream embankment face at the west abutment contact and some minor seepage from the east abutment downstream of the dam. It was reported that this seepage has been occurring since the dam was constructed with no increase in the quantity of flow. Because this dam is classified in the high hazard category, the St. Louis District recommends that this seepage be closely monitored on a continual basis to assure that piping (removal of soil particles) does not occur.

SIGNED

SUBMITTED BY

Chief, Engineering Division

27 MAR 1980

Date

SIGNED

APPROVED BY:

Colonel, CE, District Engineer

27 MAR 1980

Date

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BRAY LAKE DAM
PHELPS COUNTY, MISSOURI
MISSOURI INVENTORY NO. 30098

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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

Under Direction Of
St. Louis District, Corps of Engineers

For
Governor of Missouri

March 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

| | |
|---------------------|-------------------|
| Name of Dam: | Bray Lake Dam |
| State Located: | Missouri |
| County Located: | Phelps |
| Stream: | Abbott Branch |
| Date of Inspection: | September 7, 1979 |

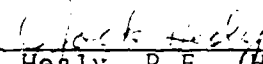
Bray Lake Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based 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 fifteen miles downstream of the dam. Located within this zone are more than forty-six dwellings (includes the city of Newburg). The dam is in the intermediate size classification, since it is greater than 40 ft high but less than 100 ft high, and the maximum storage capacity is greater than 1000 ac-ft but less than 50,000 ac-ft.

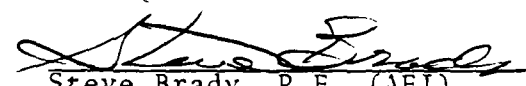
Our inspection and evaluation indicates that the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will pass 57 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of intermediate size with a high downstream hazard potential pass the PMF. The 100-year frequency flood will not overtop the dam. The 100-year flood is one that has a 1 percent chance of being equaled or exceeded in any given year.

Deficiencies visually observed by the inspection team were: (1) considerable seepage from the embankment at the west abutment-dam contact; (2) heavy weed, brush and some tree growth on embankment; (3) some animal burrows on the embankment; (4) spillway discharge channel passing down the east abutment-dam contact; (5) erosion at upper west abutment-dam contact; (6) lack of erosion protection for the upstream face of the dam; (7) wet, soft areas beyond the downstream toe of the dam; and (8) brush and weeds in the spillway outlet channel. Another deficiency was the lack of seepage and stability analysis records.


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



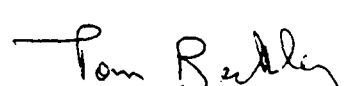
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AERIAL VIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
BRAY LAKE DAM - ID No. 30098

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-567, 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 Bray Lake Dam in Phelps 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:

Bray Lake Dam is an earth fill structure approximately 79 ft high and 1160 ft long at the crest. The appurtenant works consist of a 78 in. diameter CMP primary spillway located at the east abutment of the dam, a 10 in. diameter steel drawdown pipe and gate valve, a 12 in. diameter steel pipe used to drain a spring under the dam, and a 6 ft high levee around the entrance of the spillway pipe to maintain a higher normal pool. Sheet 3 of Appendix A shows a plan profile and typical section of the embankment.

B. Location:

The dam is located in the central part of Phelps County, Missouri on Abbott Branch. The dam and lake are within the Rolla, Missouri 7.5 minute quadrangle sheet (Section 35, T37N, R8W - latitude 37° 53.5'; longitude 91° 46.7'). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 79 ft and a maximum storage capacity of approximately 3091 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 fifteen miles downstream of the dam. Located within this zone are more than forty-six dwellings (includes the city of Newburg).

E. Ownership:

The dam is owned by Warren Dean. The owner's address is Edgar Star Route, Rolla, Missouri 65401; telephone 314-364-2539.

F. Purpose of Dam:

The dam was constructed primarily for recreation and a residential development, although some flood protection is also provided.

G. Design and Construction History:

No design information or plans are available. The dam was constructed in 1963 by Mr. L. H. Bray. Information from Mr. Bray indicates that a key trench and clay core were incorporated into the dam. The key trench is reportedly about 20 ft wide at the base and was carried down to bedrock. The key trench is about 3 ft deep at the west end of the dam and about 20 ft deep at the east end of the dam. The base of the key trench excavation was drilled with 8 to 10 ft deep holes about 6 ft apart. These holes were subsequently pressure grouted in an attempt to seal a "porous, sandy, watery" bedrock. The grout curtain was not extended up the abutments. The clay core has a minimum width of 20 ft and extends to the top of the embankment. Material for construction of the key trench and core was obtained from the hilltop on the east abutment.

A 10 in. diameter steel drawdown pipe with gate valve was built into the dam. The drawdown pipe extends about 25 ft past the upstream toe and is capable of completely draining the reservoir. The drawdown pipe is supported at each joint (every 12 or 15 ft) by a 3 ft wide, 3 ft high and 8 to 10 in. thick concrete cradle and seepage collar.

Mr. Bray reported that a spring was located just downstream of the clay core. He estimated that this spring passed about 100 gallons of water per hour. A French drain was placed around the spring and a 12 in. diameter steel pipe was installed to carry the spring water to the downstream toe of the dam. The areal extent of the French drain is unknown.

The portion of the dam upstream of the clay core was constructed with select material obtained from the lake area at least 1000 ft upstream of the dam. The downstream portion of the embankment was constructed of less select material. Mr. Bray indicated that good compaction and water content control was utilized during construction.

No spillway was provided for the dam. Seepage from the west embankment face has occurred since completion of construction in 1963 (see Photo No. 21). Mr. Bray reported that the dam has never overtopped.

Immediately prior to selling the dam and lake area to Warren Dean in 1973, Mr. Bray initiated blasting operations in the west abutment to form a rock cut spillway. This spillway was never completed.

After purchasing the dam in 1974, Warren Dean reported that he lowered the lake about 13 ft to clear trees in the lake around the shoreline and to deepen the lake around the perimeter. He noted that it took about 45 days to lower the lake 13 ft. In 1975, the 78 in. diameter corrugated metal pipe was installed in the east end of the dam. An 8 in. diameter plastic sewer pipe was installed from the east abutment upstream of the dam to the lagoons below the dam. Mr. Dean indicated that the plastic sewer pipe passes under the spillway pipe. A berm was placed around the spillway inlet area during installation of the pipe (see Photo No. 8). An 8 in. diameter clay pipe (see Photo No. 10) passes through the berm on the west side of the spillway inlet area. An 8 in. diameter plastic pipe passes through the berm on the north side of the spillway inlet area. The outlet of this 8 in. plastic pipe is over the open end of an

inclined plastic pipe that is reported to be connected to the sewer line passing under the CMP spillway pipe. It appears that any discharge from the 8 in. plastic spillway pipe would drop into the flanged end of the inclined plastic pipe. (see Photo No. 9). A diversion channel just above the downstream berm was cut to direct the seepage at the west end of the dam away from the embankment.

H. Normal Operating Procedures:

The normal flows are discharged through an uncontrolled pipe spillway. A 10 in. diameter steel pipe can be used for the drawdown of the lake. The dam has never been overtopped, and the spillway has reportedly never operated.

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 686 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. 963.2): 360 cfs
- (3) Estimated Capacity of Primary Spillway: 360 cfs
- (4) Estimated Experienced Maximum Flood at Dam Site: Outflow less than 1 cfs (At high water mark, 956.0 ft M.S.L.)
- (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 in feet above M.S.L., and are consistent with site benchmarks established during a survey in February, 1975 (see Sheets 3 and 4, Appendix A).

- (1) Top of Dam: 963.2 (Low Point); 965.6 (High Point)
- (2) Principal Spillway Crest: 955.5
- (3) Emergency Spillway Crest: Not Applicable
- (4) Principal Outlet Pipe Invert: Not Applicable
- (5) Streambed at Centerline of Dam: 887.0
- (6) Pool on Date of Inspection: 954.6
- (7) Apparent High Water Mark: 956.0
- (8) Maximum Tailwater: Unknown
- (9) Upstream Portal Invert Diversion Tunnel: Not Applicable
- (10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

- (1) At Top of Dam: 4730 ft
- (2) At Principal Spillway Crest: 4200 ft
- (3) At Emergency Spillway Crest: Not Applicable

E. Storage Capacities:

- (1) At Principal Spillway Crest: 2192 acre-ft
- (2) At Top of Dam: 3091 acre-ft
- (3) At Emergency Spillway Crest: Not Applicable

F. Reservoir Surface Areas:

- (1) At Principal Spillway Crest: 96 acres

- (2) At Top of Dam: 123 acres
- (3) At Emergency Spillway Crest: Not Applicable

G. Dam:

- (1) Type: Earth
- (2) Length at Crest: 1160 ft
- (3) Height: 79 ft (maximum)
- (4) Top Width: 28 ft
- (5) Side Slopes: Upstream Varies; Downstream Varies (see Sheet 3, Appendix A)
- (6) Zoning: Select material upstream of clay core (from Mr. Bray).
- (7) Impervious Core: Minimum width of 20 ft (from Mr. Bray).
- (8) Cutoff: Key trench (carried to bedrock and up both abutments to the top of the dam) 20 ft wide and 3 to 20 ft deep (from Mr. Bray).
- (9) Grout Curtain: 8 to 10 ft below base of key trench on 6 ft centers (from Mr. Bray).

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: East Abutment
- (2) Type: 78 in. CMP

I.2 Emergency Spillway:

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

J. Regulating Outlets:

The only regulating outlet for Bray Lake Dam is a 10 in. diameter steel pipe that can be used for the drawdown of the lake. The pipe runs through the embankment at the west abutment and has a control gate valve at the discharge end. The control gate valve is located inside a metal manhole. It was found to be operable on the date of inspection.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

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

A. Surveys:

No information regarding pre-construction surveys could be obtained. Only a general layout map made in 1975 by J. R. Hubbard (shown in Sheet 4, Appendix A) was obtained. Sheet 3 of Appendix A presents a plan, profile and cross section of the dam from survey data obtained during the site inspection. Benchmarks utilized in the inspection survey are described on Sheets 3 and 4 of Appendix A.

B. Geology and Subsurface Materials:

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

The publication "The Geology of the Rolla Quadrangle" indicates that the bedrock in the area of the dam and lake is the Roubidoux formation of the Canadian Series in the Ordovician System. The Roubidoux formation is the most widely exposed formation in the Rolla quadrangle, and consists of sandstone, dolomitic sandstone and cherty dolomite. The beds of the Roubidoux are, as a whole, nonresistant to weathering. Consisting of alternating thin beds of chert, quartzite, sandstone and thin-bedded dolomites, the formation is easily broken down. The publication "Caves of Missouri" indicates that at least 56 caves exist in Phelps County. Of these caves, at least five caves are located in the Rolla quadrangle and eleven caves are in the adjacent Yancy Mills quadrangle. All of the 14 caves which are within ten miles of the site are clustered to the west and southwest.

The "Geologic Map of Missouri" indicates several normal faults about 30 miles east and northeast of the 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.

Information from the United States Department of Agriculture Soil Conservation Service indicates that soils in the watershed area of Bray Lake are comprised of the following soil types:

| <u>Soil Type</u> | <u>Percent of Watershed</u> |
|------------------------------|-----------------------------|
| Lebanon silt loam | 10% |
| Hobson loam | 5% |
| Clarksville cherty silt loam | 35% |
| Coulstone cherty loam | 25% |
| Bardley silt loam | 25% |

The Lebanon and Hobson soils are generally located in upland areas and are well-drained. The Clarksville soils, which occupy the largest percentages of the watershed area, are positioned on the steeper slopes. These soils are reddish silty clays derived from cherty and dolomitic limestones. The Coulstone soils are generally a yellowish-brown to brown friable cherty sandy clay loam, and are formed in material weathered from dolomite and sandstone. The Bardley series subsoils consist of a red to dark red clay derived from weathered dolomite. Sheet 3 of Appendix B presents a breakdown of the areas covered by the various soil types in the watershed.

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. A key trench and clay core are reportedly provided, with select material comprising the embankment upstream of the clay core. A French drain and outlet pipe are utilized to drain a spring which is located immediately downstream of the clay core. No construction inspection test results have been obtained.

D. Hydrology and Hydraulics:

No hydrologic or hydraulic design computations for Bray Lake Dam are available. Based on a field check of spillway dimensions and embankment elevations, and the drainage area planimetered from the U.S.G.S. quad sheet, hydrologic analyses using U.S. Army Corps of Engineers guidelines were performed and appear in Appendix C, Sheets 1 to 7. It was concluded that the structure will pass 57 percent of the Probable Maximum Flood without overtopping. The 100-year frequency flood will not overtop the dam.

E. Structure:

No design information for the appurtenant structures was obtained.

2.2 CONSTRUCTION:

No construction inspection data have been obtained.

2.3 OPERATION:

Normal flows are discharged through an uncontrolled pipe spillway. The only regulating facility associated with this dam is the 10 in. pipe used for the drawdown of the lake. The heavy brush and weed growth indicates that the embankment and the inlet and outlet channels for the spillway have not been maintained.

2.4 EVALUATION:

A. Availability:

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

B. Adequacy:

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

C. Validity:

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

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on September 7, 1979. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

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

Accompanying the inspection team was Mr. Dave Hoffman of the Missouri Department of Natural Resources.

B. Dam:

The dam appears to be in generally good condition. A considerable seepage flow (estimated at between 300 and 400 gallons per minute) was exiting from a small area on the downstream embankment face (at the west abutment contact) at about Station 9+00 (see Sheet 4, Appendix A). The seepage was carried away from the embankment by a channel cut into the west abutment downstream of the dam (see Photo No. 22). Several small pipes discharge water from the diversion channel down the west abutment (see Photo No. 23). Soil particles were not observed in the seepage flow. However, the diversion channel below the seepage exit area contained significant sediment deposits. This seepage has reportedly been occurring since construction of the dam, with no obvious increase in quantity. Mr. Bray indicated that the water is apparently passing through an area at the west abutment which was not grouted. Although water has leaked in this area since construction of the dam, no seepage through the embankment was noted during the inspection.

High weeds, scattered brush and some trees were noted along both the upstream and downstream embankment faces. Some animal burrows were observed on the downstream face near the crest of the dam. Some erosion was noted at the upper west abutment-dam contact. The horizontal and vertical

alignments of the crest appeared good, and no surface cracking or unusual movement was obvious. No erosion protection is provided for the upstream face of the dam, although no erosion or sloughing was observed. Shallow auger probes into the embankment indicated the dam to consist of a brown and brownish red silty clay with rock fragments. Information from Mr. Bray indicates that material for construction of the embankment was obtained from the lake area no closer than 1000 ft from the dam site. Select material for the clay core was obtained from the east abutment hillside.

The spillway outlet channel passes down the east abutment-dam contact. Some seepage (estimated at about 5 gallons per minute) was exiting from the outlet channel. The owner reported that this is leakage from the sewer line which passes under the spillway pipe and goes to the lagoons downstream of the dam. The location of this sewer line was not evident to the inspection team.

Some additional minor flows were observed from the east abutment downstream of the dam. These are possible springs exiting downstream of the dam on the east abutment. Several wet, soft areas (portions possibly due to poor drainage) were noted beyond the downstream toe of the embankment. No instrumentation (monuments, piezometers, etc.) was observed.

C. Appurtenant Structures:

C.1 Primary Spillway:

Some brush and weeds were observed in the inlet and outlet channels of the spillway. The inlet of the spillway pipe is surrounded by a 6 ft high levee to raise the level of the pool. The spillway pipe appears to be salvage material. Three large holes are cut into the top of the pipe, and steel plates are bolted over the holes. The pipe is deformed somewhat, so that it is out of round. The outlet of the spillway pipe is directed toward a natural rise, which diverts the flow. The outlet channel turns abruptly and passes down the east abutment-dam contact (see Photos 13 and 14).

C.2 Emergency Spillway:

There is no emergency spillway associated with Bray Lake Dam.

C.3 Drawdown Pipe:

The 10 in. diameter steel drawdown pipe and valve appeared to be in good condition (operated on day of inspection). The 12 in. diameter steel pipe, which reportedly drains a spring under the dam, also appeared in good condition.

D. Reservoir:

The watershed is generally wooded and grassy. A small (17 acre) limestone quarry is located near the edge of the watershed. The slopes adjacent to the lake are moderate and rolling, and no sloughing or serious erosion was noted.

E. Downstream Channel:

Several empty lagoons and a pond are located immediately downstream of the dam. The valley is fairly wide and clear of trees, although considerable weeds and some brush is present.

3.2 EVALUATION:

The considerable seepage at the west abutment-dam contact is very serious, and could initiate a piping failure of the dam if not corrected. Trees and brush on the dam constitute a potential seepage hazard and encourage animal burrowing. The erosion at the west abutment-dam contact, the presence of the spillway outlet channel at the east abutment-dam contact, and the wet, soft areas beyond the toe of the embankment could adversely affect the stability of the dam.

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

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

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

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

The only controlled outlet works for this dam is the 10 in. diameter steel drawdown pipe. The spillway is uncontrolled, so that the lake is normally controlled by seepage, rainfall, runoff, and evaporation.

Mr. Dean indicated that the lake was drawn down about 13 ft in 1974 in order to perform work around the shoreline. The lake was also drawn down a few feet when the spillway pipe was installed.

4.2 MAINTENANCE OF DAM:

The tree, brush, and weed growth indicates that the embankment and the spillway inlet and outlet channels have not been maintained in recent years.

4.3 MAINTENANCE OF OPERATING FACILITIES:

The gate valve and the pipe for the drawdown facilities appear to be in good condition. It is not known whether the valve is inspected or opened periodically.

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 seepage areas as previously described, soft, wet areas beyond the downstream toe of the dam, trees and brush on the dam, erosional areas, animal holes on the downstream embankment face, lack of erosion protection for the upstream face of the dam, and the presence of the spillway outlet channel at the east abutmentdam contact are serious deficiencies which should be corrected. To avoid creating an unsafe condition, this should be done under the direction of an engineer experienced in the design and construction of dams.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. & B. Design and Experience Data:

The hydraulic and hydrologic analyses were based on: (1) a field survey of spillway dimensions and embankment elevations; and (2) an estimate of the pool and drainage areas from the U.S.G.S. quad sheet. Mr. Bray reported that despite the absence of a spillway when he owned the dam (1963 to 1974), the embankment was never overtopped. Mr. Dean indicated that the 8 in. plastic pipe, which discharges into the sewer line, has operated once, when the lake level was about 6 in. above the pipe invert. The 8 in. diameter clay pipe and 78 in. diameter CMP have reportedly never operated. Our hydrologic and hydraulic analyses using U. S. Army Corps of Engineers guidelines appear in Appendix C.

C. Visual Observations:

The 6 ft high levee around the entrance of the spillway pipe permits an increase of the pool elevation without a significant outflow through the pipes. Almost all the inflow to the lake is storage until the water overtops the levee crest. This delays the outflow capability of the spillway and increases the possibility of overtopping.

The right-angle turn in the outlet channel and the brush and weed growth restrict the outflow of the spillway. The spillway channel passes down the east abutment-dam contact.

D. Overtopping Potential:

Based on the hydrologic and hydraulic analysis presented in Appendix C, the spillway will pass 57 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this structure (intermediate size with high downstream hazard potential) pass the PMF, without overtopping. The structure will pass a 100-year frequency flood without overtopping.

The routing of the PMF through the spillway and dam indicates that the dam will be overtopped by 2.53 ft at elevation 965.73. The duration of the overtopping will be 9.33 hours, and the maximum outflow will be 2721 cfs. The maximum discharge capacity of the spillway is 360 cfs. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure. Considering the significant height and duration of overtopping, serious damage to the dam would be expected to occur.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

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

B. Design and Construction Data:

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

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

Reported post-construction changes include partial blasting of a spillway at the west abutment and installation of a sewer line, spillway pipe and construction of the berm surrounding the spillway inlet area.

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) considerable seepage from the embankment at the west abutment-dam contact; (2) heavy brush and weed growth and some trees on the embankment face; (3) some animal burrows on the embankment; (4) spillway discharge channel passing down the east abutment-dam contact; (5) erosion at upper west abutment-dam contact; (6) lack of erosion protection for the upstream face of the dam; (7) wet, soft areas beyond the downstream toe of the dam; and (8) brush and weeds in the spillway outlet channel.

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

The dam will be overtopped by flows in excess of 57 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 on a high priority basis.

D. Necessity for Phase II:

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

E. Seismic Stability:

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

7.2 REMEDIAL MEASURES:

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

A. Alternatives:

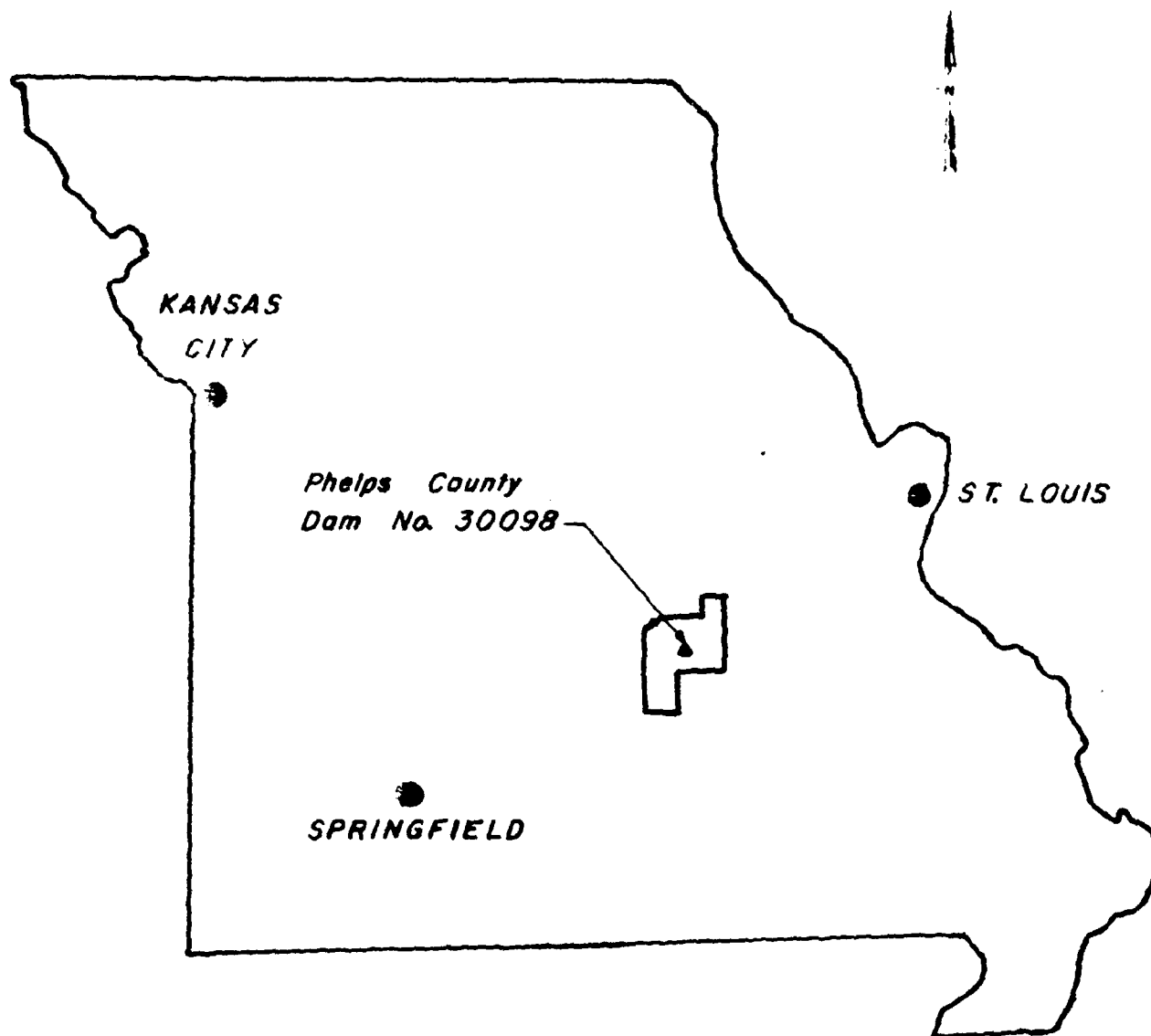
- (1) Spillway size and/or height of dam should be increased to pass the PMF. In either case, the spillway should be protected to prevent erosion.

B. O&M Procedures:

- (1) The seepage from the embankment face at the west abutment-dam contact should be investigated by an engineer experienced in the design and construction of dams. Remedial measures will be required. As a minimum, this seepage should be monitored to determine if there is any increase in quantities and whether soil particles are being carried with the water.
- (2) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the construction of dams.

- (3) Brush and tree growth should be removed from the dam and from the spillway outlet channel. 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. Brush and tree growth should then be removed from the dam on an annual basis.
- (4) Wave erosion protection should be provided for the upstream face of the embankment.
- (5) The animal holes on the downstream face of the dam should be repaired and maintained.
- (6) The erosion at the west abutment-dam contact should be corrected and maintained.
- (7) The spillway outlet channel should be diverted away from the abutment-dam contact.
- (8) The valve on the drawdown pipe should be opened periodically to insure that it is operable.
- (9) Positive drainage should be provided for the wet areas along the toe of the dam. These areas should periodically be monitored to detect possible seepage problems.
- (10) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

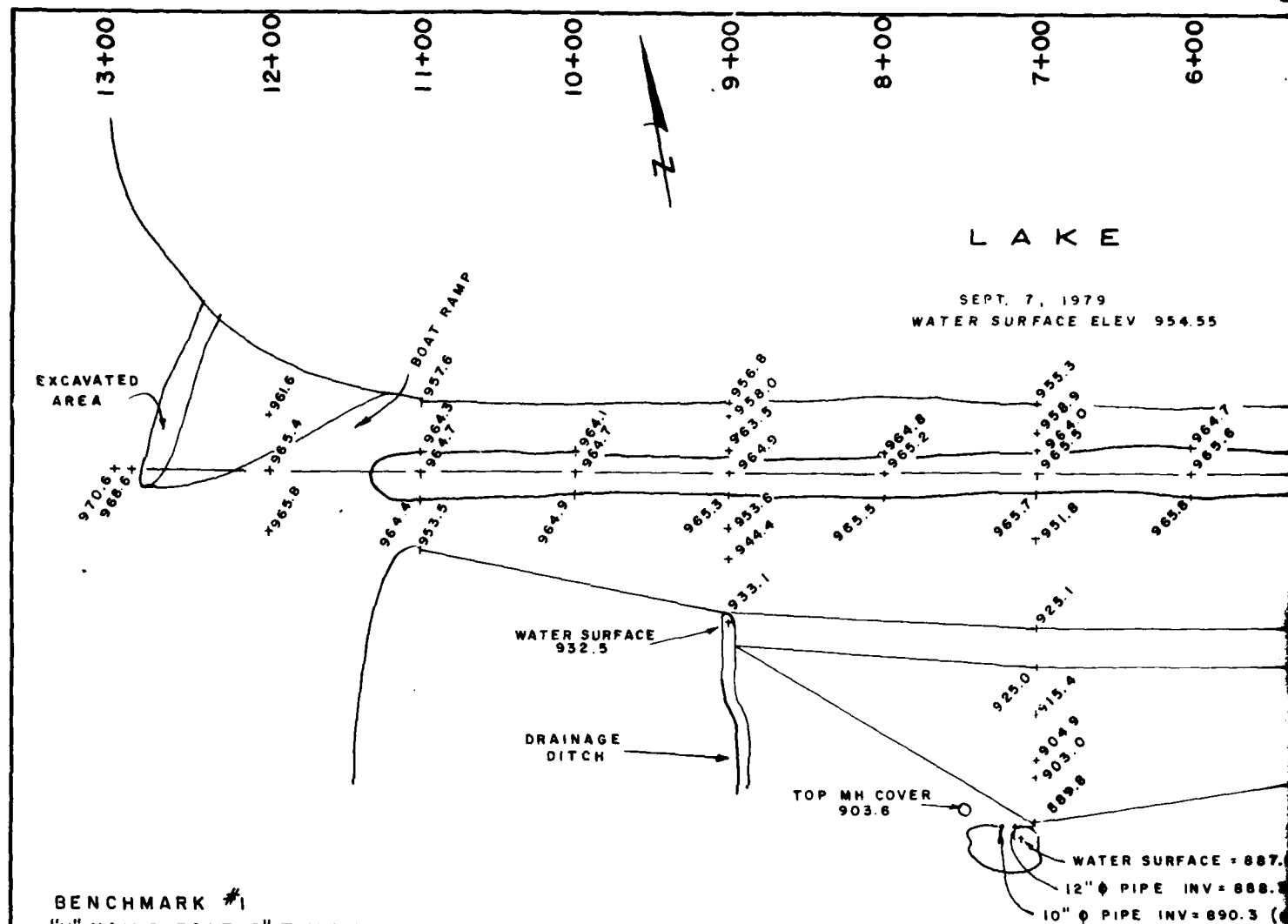
APPENDIX A



LOCATION MAP



SITE VICINITY MAP



BENCHMARK #1

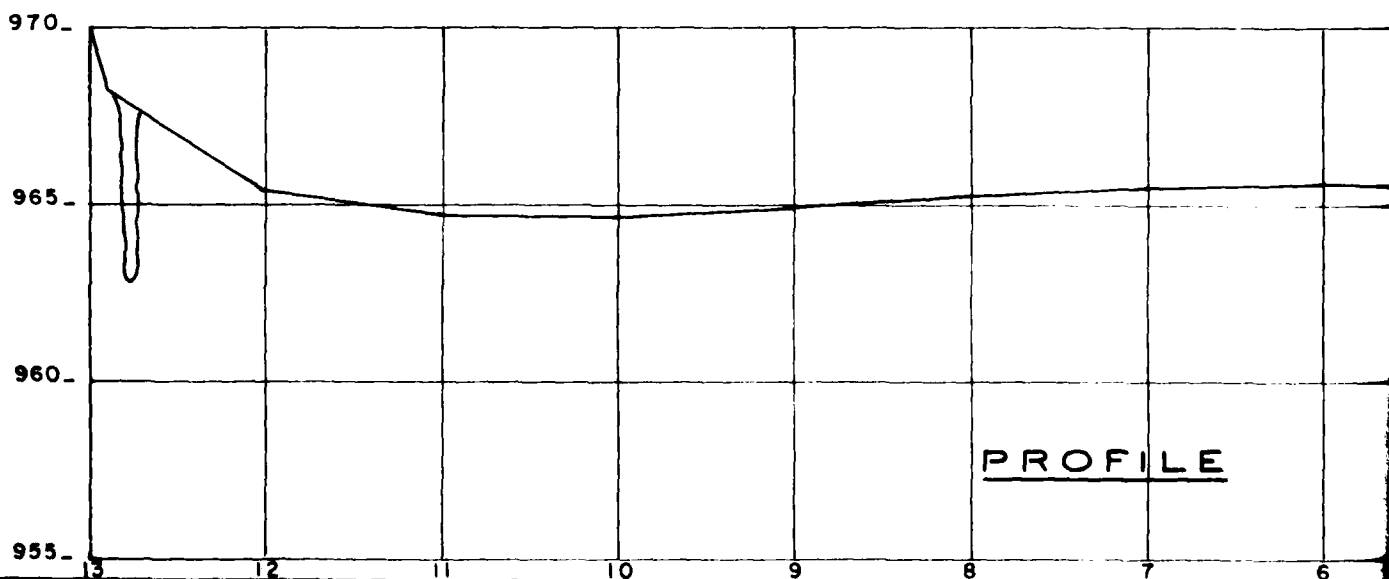
"X" NAILS ROOT 8" TWIN HICKORY
150 FT. NORTH STA 12+90 ELEV. = 963.13 MSL

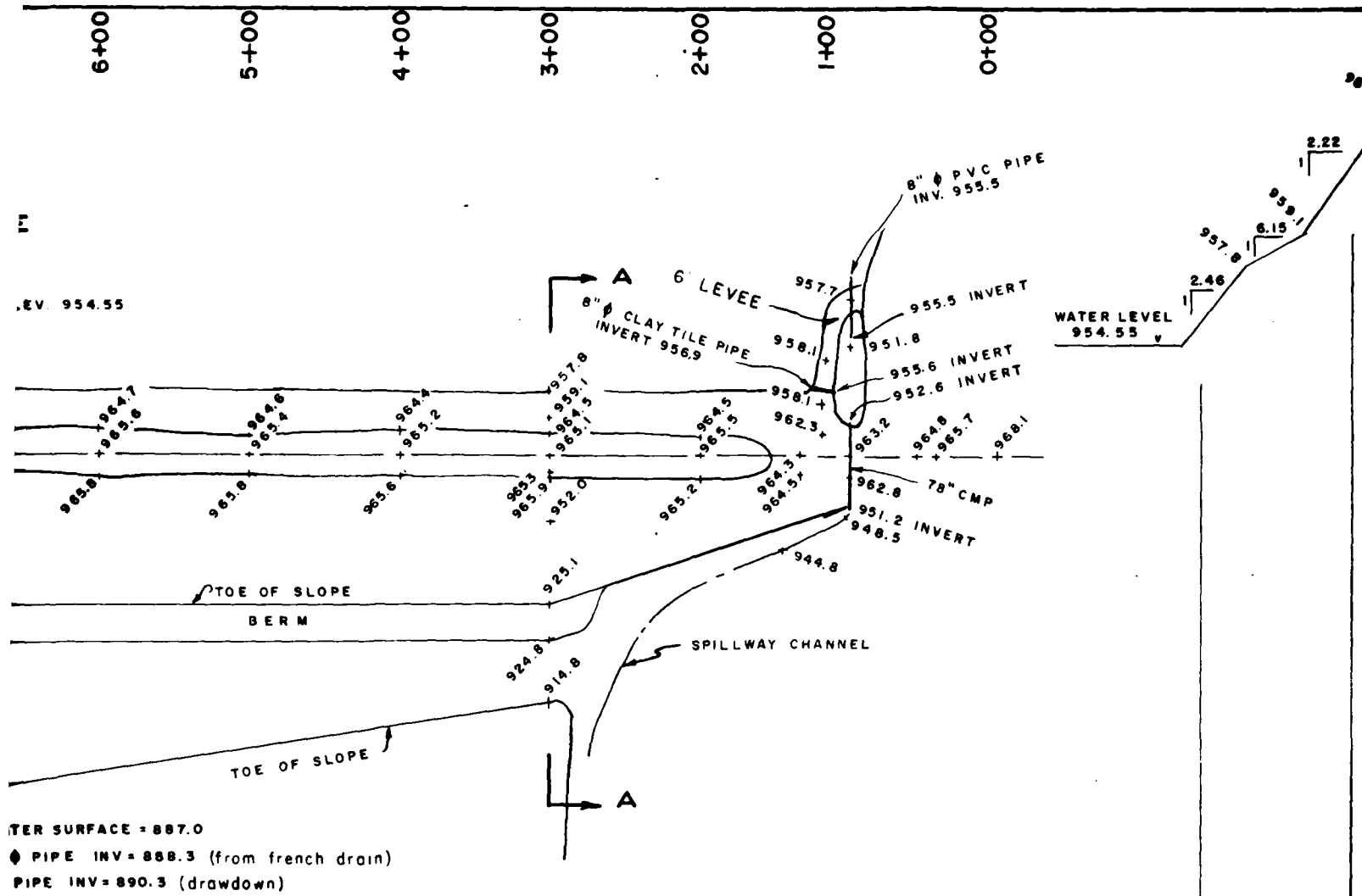
BENCHMARK #2

"X" NAILS IN ROOT 30" TWIN OAK
20 FT. NORTH STA 0+15 ELEV. = 968.99 MSL

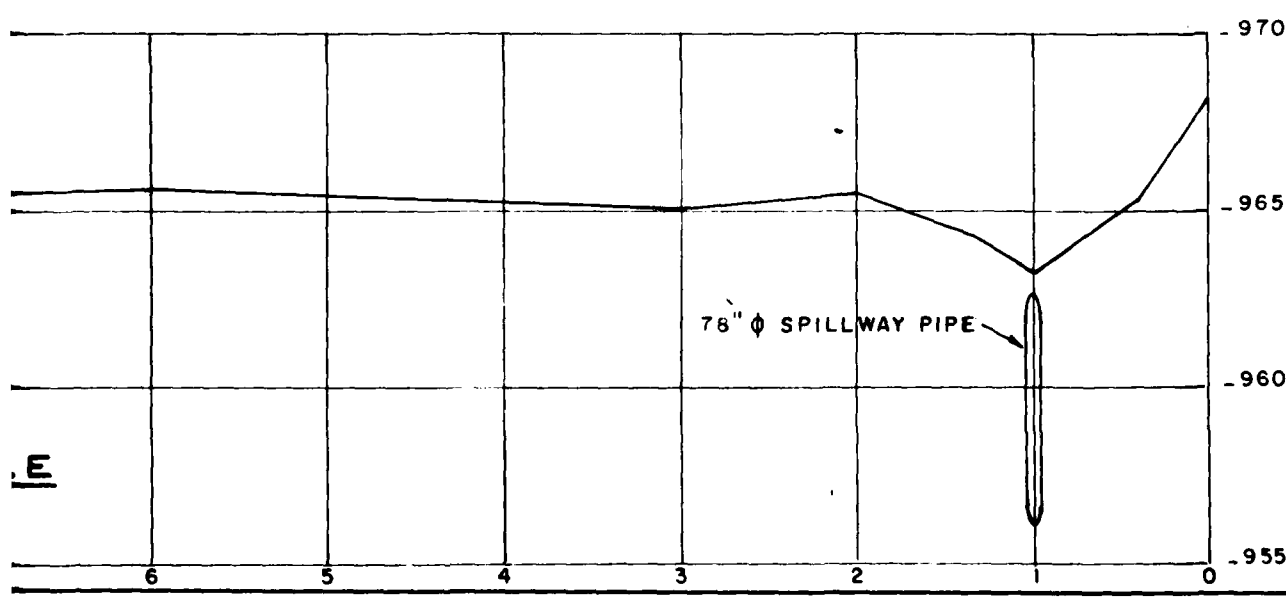
PLAN VIEW

SCALE 1" = 100'





IEW
30

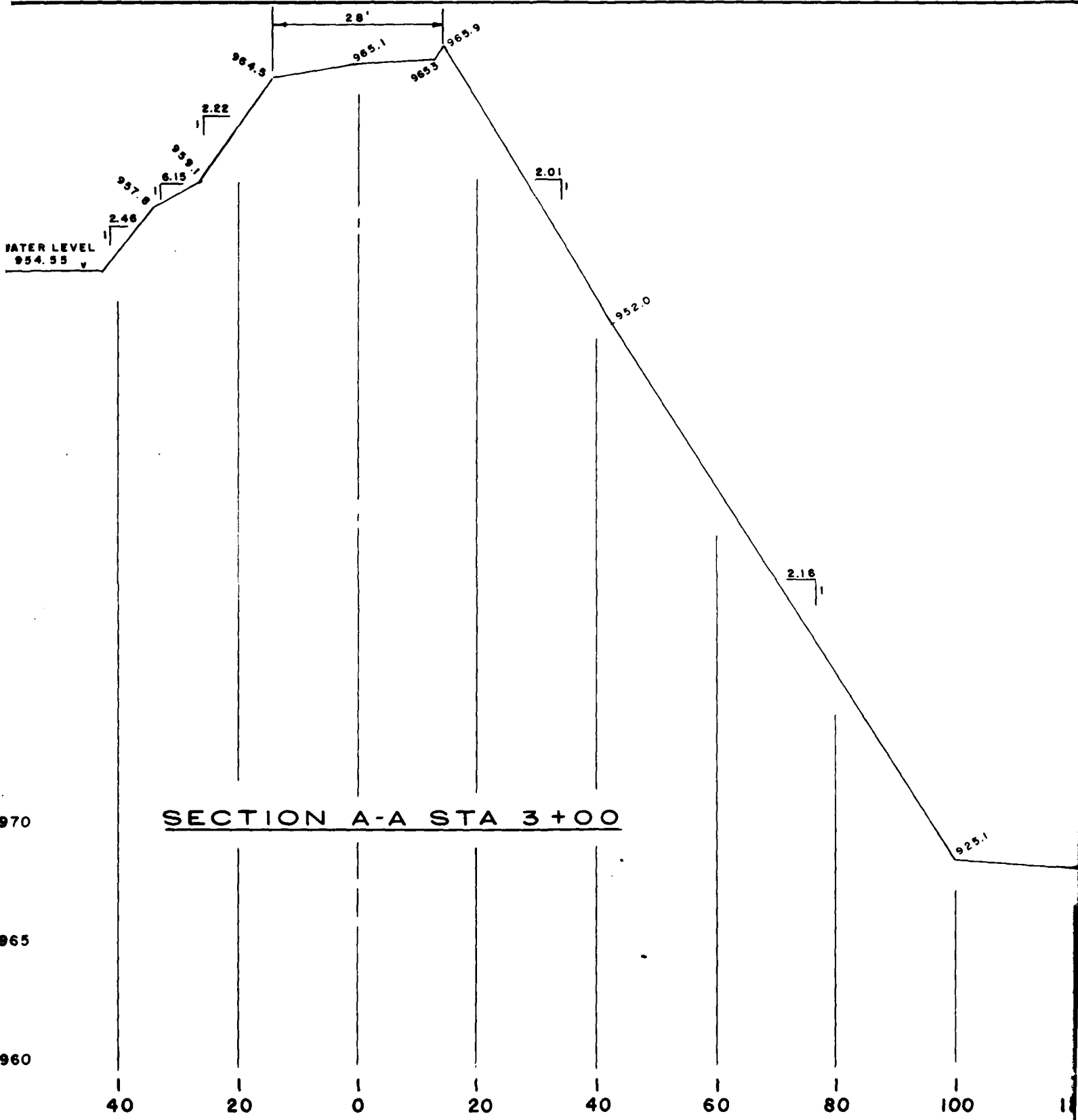


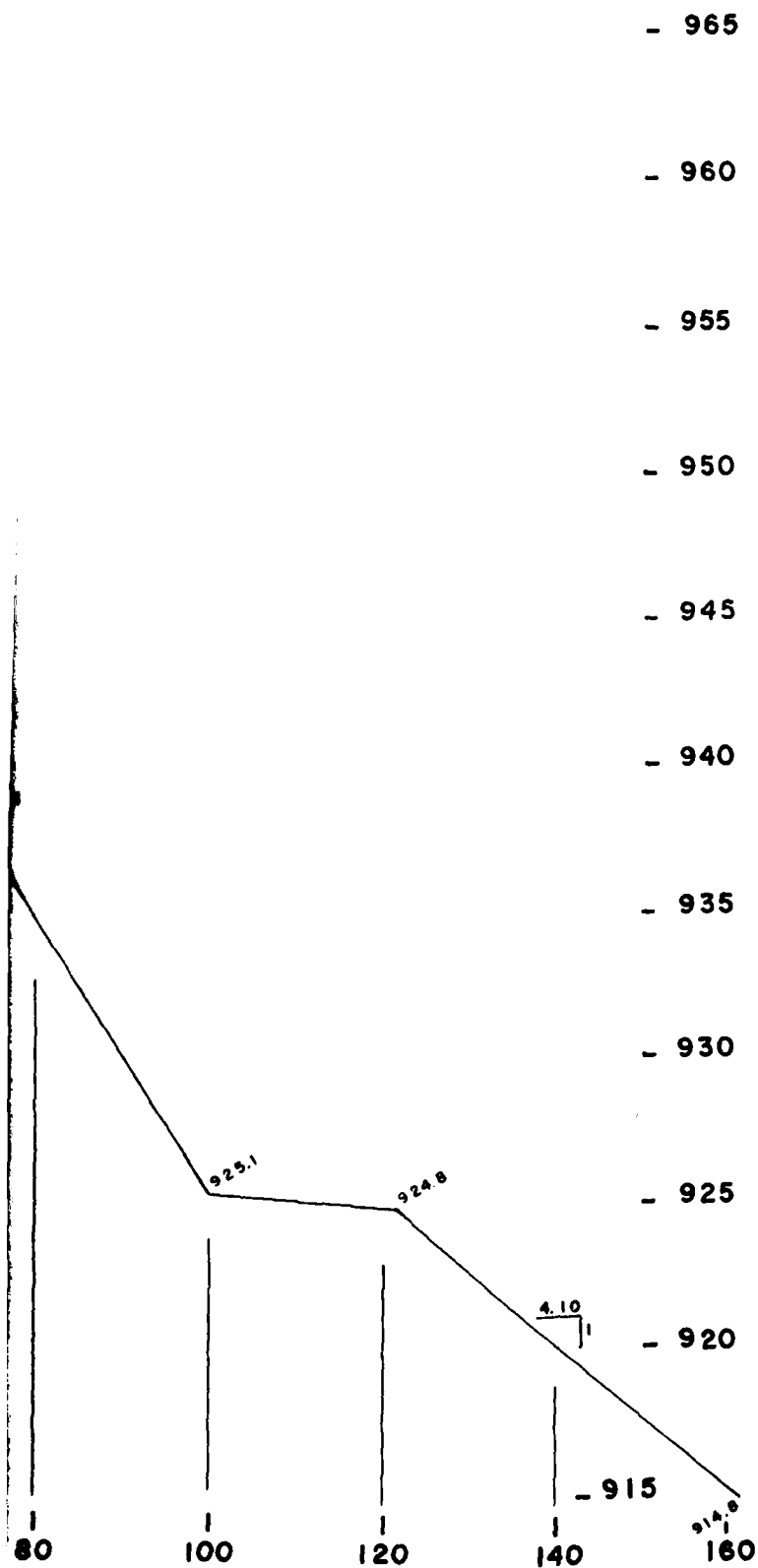
SECT

40

20

12





Sheet 3 of Appendix A

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

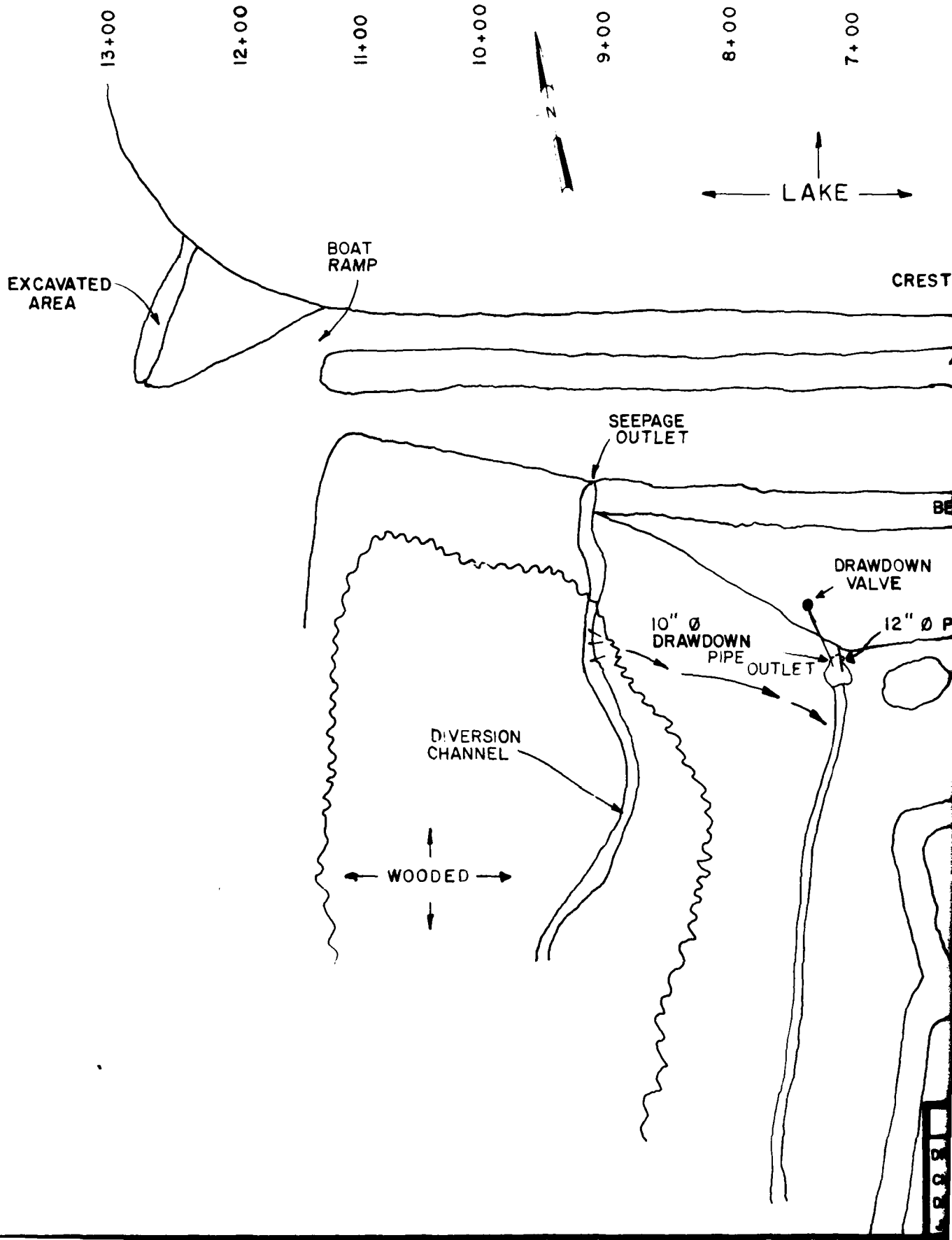
BRAY LAKE

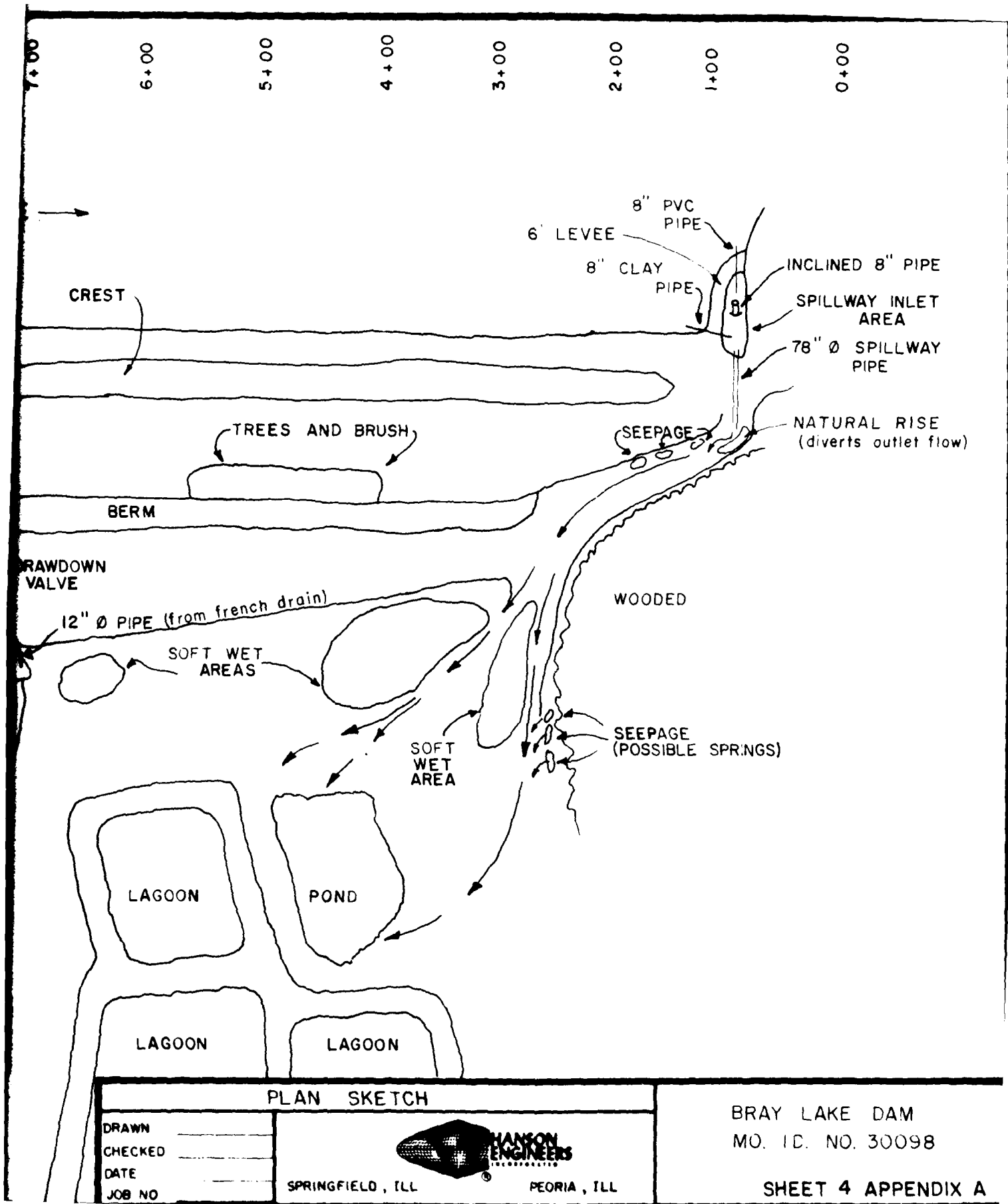
MO. No. 30098

PLAN & PROFILE

PHELPS COUNTY, MO.

A

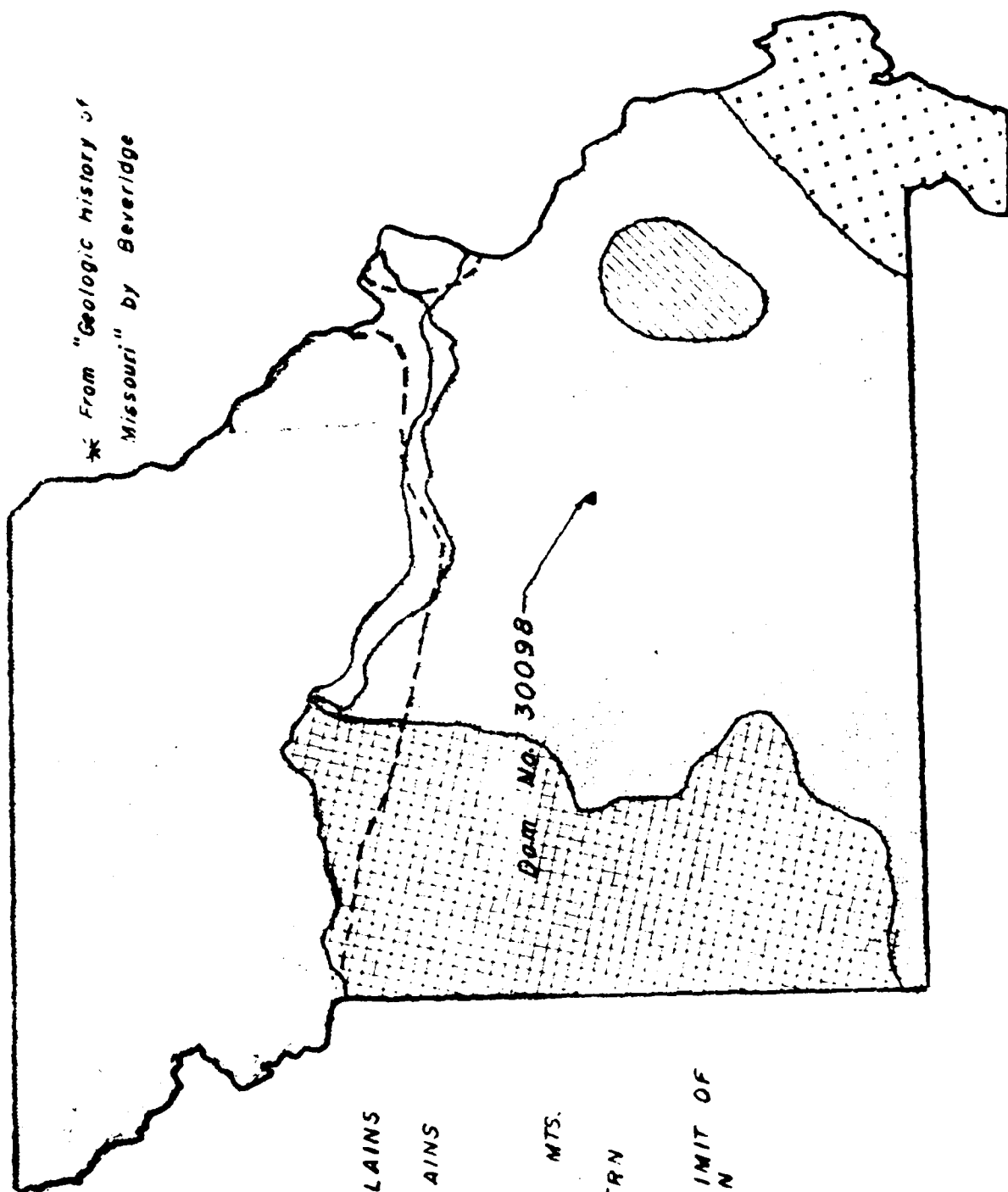




APPENDIX B

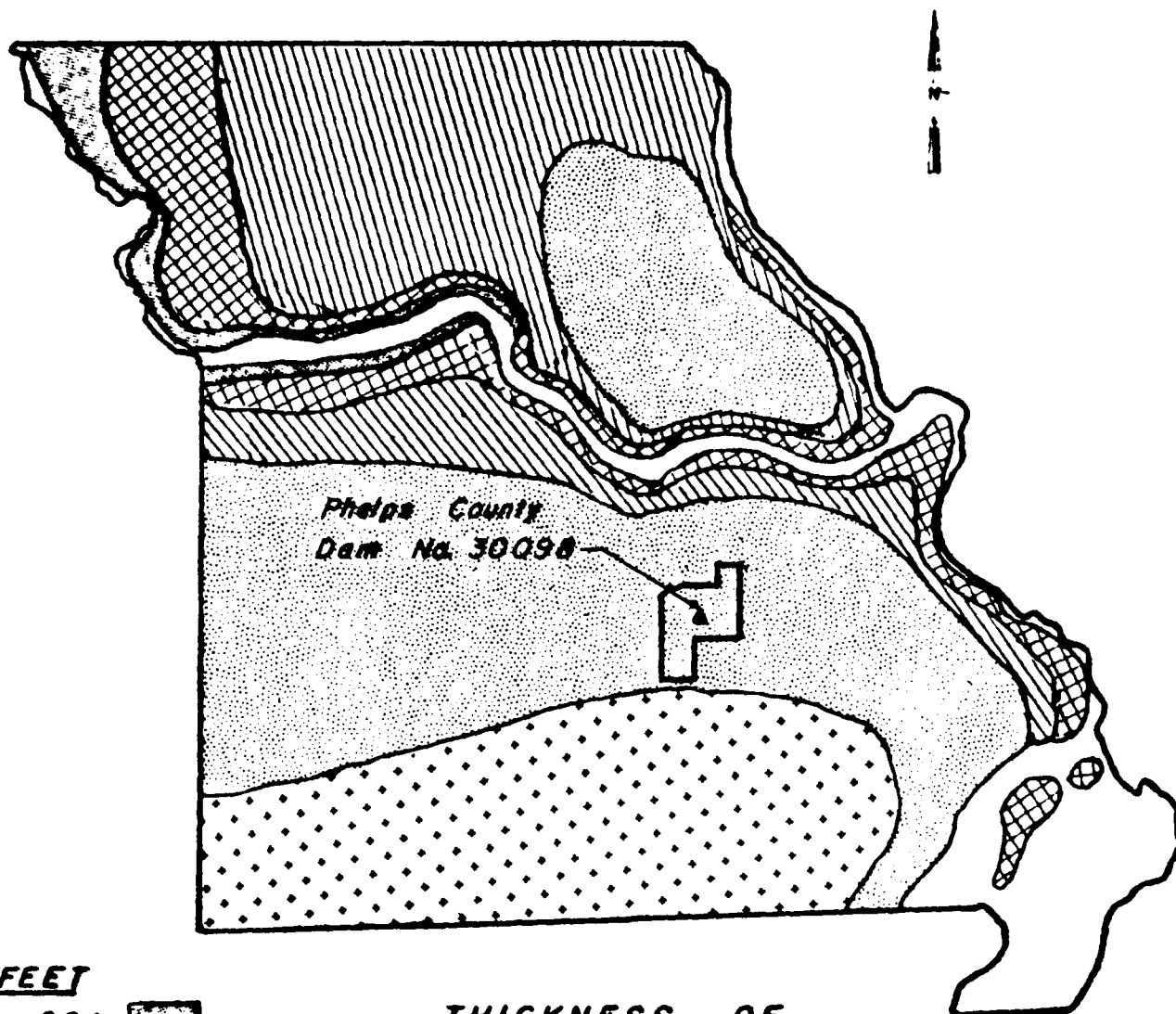
MAJOR GEOLOGIC REGIONS OF MISSOURI






* From "Geologic history of Missouri" by Beveridge



- GLACIATED PLAINS
- WESTERN PLAINS
- OZARKS
- ST. FRANCOIS MTS.
- SOUTHEASTERN LOWLANDS
- SOUTHERN LIMIT OF GLACIATION

* From "Soils of Missouri"



| <u>FEET</u> | |
|-------------|---|
| 20+ |  |
| 10-20 |  |
| 5-10 |  |
| 2.5-5 |  |
| 2.5- |  |

THICKNESS OF
LOESSIAL DEPOSITS

SHEET 2 OF APPENDIX B

May 17, 1979

Bray's Lake Watershed

| <u>Soil and slope</u> | <u>Acerage</u> |
|---|----------------|
| Lebanon silt loam, 2 to 5 percent slopes | 48 |
| Hobson loam, 2 to 5 percent slopes | 27 |
| Hobson loam, 5 to 9 percent slopes | 7 |
| Clarksville cherty silt loam, 5 to 9 percent slopes | 29 |
| Clarksville cherty silt loam, 9 to 14 percent slopes | 9 |
| Clarksville cherty silt loam, 14 to 50 percent slopes | 167 |
| Coulstone cherty loam, 5 to 9 percent slopes | 65 |
| Coulstone cherty loam, 9 to 14 percent slopes | 40 |
| Coulstone cherty loam, 14 to 50 percent slopes | 37 |
| Bardley silt loam, 5 to 9 percent slopes | 99 |
| Bardley silt loam, 9 to 14 percent slopes | <u>45</u> |
| | 573 |
| Limestone Quarry | 17 |
| Lake | <u>125</u> |
| Total | 715 |

STATE OF
MISSOURI

*Helps Co.
Reservoir*

DIVISION OF GEOLOGICAL SURVEY AND WATER RESOURCES

BUEHLER PARK

ROLLA MISSOURI 65401

314-364-1752

WILLIAM C. HAYES STATE GEOLOGIST AND DIRECTOR

WALLACE B. HOWE ASSISTANT STATE GEOLOGIST

February 5, 1970

To Whom It May Concern:

Bray's lake is located in the South $\frac{1}{2}$ of section 26, T. 37 N., R. 8 W.

Computations with a compensating polar planimeter indicate the lake size is approximately 96 surface acres with a drainage area of about 650 acres. Computations are made from a U.S.G.S. 7 $\frac{1}{2}$ -minute quadrangle map, assuming a spillway elevation of 965 feet.

The lake to drainage ratio, about 6:1 is thought to be low, so during dry years the lake level may fluctuate 3 to 5 feet through normal seepage and evaporation.

The geologic setting of the lake indicates that a stable pool can be maintained. The 3 to 5 feet of fluctuation is a normal change due to seasonal and yearly rainfall variations. There is no geologic evidence that a catastrophic failure of sudden water loss would occur.

The relatively small watershed has the advantage in that a clear pool of sediment free water can be expected. It has the disadvantage in that seasonal fluctuations during drought years can be greater. Another favorable small watershed feature is the lessening of the hazard of overtopping the dam due to intense storms. However, an intense rain, especially on frozen ground, should be expected to cause water flow through the spillway.

James H. Williams

James H. Williams
Geologist and Chief
Engineering Geology
Missouri Geological Survey

Philip

For File Only

BRAY'S LAKE SITE

Revisit to Bray's Lake site located in SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 27, T. 37 N., R. 8 W., Rolla Quadrangle, indicated that there is yet to be constructed a spillway. Water level is approximately 12 feet below the crest of the dam. There has been a drop of 1 to 2 feet of water level during the winter and spring season. However, for all practical purposes, the waterline has appeared to have remained relatively stable. Leakage is still continuing on the right valley slope downstream of the dam site. Water temperature at this time of the year was approximately 41° F. at the upper leakage. Leakage is also occurring at the lowermost toe of the dam in the old stream channel. The water temperature here was 40°. This included water flowing from a pipe which apparently had been placed through the bottom of the dam. Other than the absence of a spillway and the leakage described above, there are no obvious hazards which would indicate structural failure or other suitable conditions with this lake.

James H. Williams

James H. Williams
Geologist and Chief
Engineering Geology
Missouri Geological Survey
20 April 1970

BRAY LAKE SITE

Phelps County, Missouri

LOCATION: NE $\frac{1}{4}$, NW $\frac{1}{4}$, Sec. 35, T.37N., R.8W.

On May 2, 1974, I inspected the valley downstream of the dam for a proposed lagoon site. The lagoon is part of a development being planned by Warren Dean. Mr. Warren Dean accompanied me on the inspection. After the lagoon site inspection was completed, we walked over the downstream slope of the dam. Mr. Dean pointed out the leak on the west abutment. The leak is described in Jim Williams's report dated April 20, 1970. There is a berm on the downstream side of the slope which Mr. Dean said consists primarily of boulders and gravel with a covering of topsoil. Some of the water from the leak flowed on the surface of the berm for a distance about half way across the dam. At that point the water went over the edge of the berm and down the sides of the slope. I suspect some of the water was also percolating through the top of the berm and coming out on the downstream slopes as there were several clumps of cattails on the slopes and at the toe of the dam.

Mr. Dean is going to construct a pipe so that all the leakage water is diverted away from the berm and directed downslope. By doing this the water appearing on the downstream slope of the berm should dry up unless it is coming through the body of the dam.

Mr. Dean plans to excavate a spillway on the west side of the dam and also a culvert on the east side of the dam. The water level in the dam was 7 to 8 feet below the top of the dam during the time of inspection.



John W. Whitfield, Geologist
Applied Engineering & Urban Geology
Missouri Geological Survey
May 6, 1974

155
DEAN LAKE SITE
(Formerly Bray)

Phelps County, Missouri

I visited your lake site accompanied by Dave Rath who is in charge of the inventory portion of the dams in Missouri. This project as you may well know is a part of the Congressional directive to determine the number of dams in the United States that are over a certain height. It has nothing to do with determining the structural soundness of a dam, but the verbal comment to us on this dam by the inventory team prompted the visit by Rath and myself.

The point of my letter is that I have periodically visited the dam when it was owned by Mr. Bray. A number of people had inquired as to the suitability of that structure for possible purchase. My reports, while in no way an engineering evaluation, included that the dam was in excellent shape, geologically.

The lack of a spillway was mentioned. There was a leak noted on the right (west) side of the valley, but it appeared to be water seeping around the dam through bedrock. I could see no problems of deterioration caused by this leak. However, on the revisit this time we observed a major leak on the right side of the dam (west side) which is one I think that warrants your attention. There is a large quantity of water flowing through here. It is flowing under head at or near the dam and bedrock abutment contact. The effects of this flow seems to be a gradually weakening of the soil and perhaps bedrock. I think it merits attention and likely will need to be sealed by grouting.

I am also concerned about what may happen with the development of a spillway with this dam. The original spillway on the west side appeared to have been well located with regards to sound bedrock. Unfortunately it was never completed. I don't know what you have in mind on the east side of the dam. If you intend to construct a spillway here I am afraid you are going to run

into extremely serious erosion problems. Also, if the trench that is being dug on this site is for a sewer line, piping along that line will occur unless anti-seep collars are installed.

I probably can't offer much more in the way of specifics since the actual engineering design on the dam is not within our phase of work. However, I would be glad to discuss with you the subjects that I touched on. I called your office and they indicated that you weren't there. They did point out they would contact you to tell you we were planning to come out to the site so you could meet us there if you were free. I would be glad to revisit the site with you at some mutually convenient time to point out these problems that you have been discussing.

J. Hadley Williams
Geologist and Chief
Applied Engineering & Urban Geology
Missouri Geological Survey
June 25, 1974

Warren Dean Lake Site
(Formerly Bray's)

Phelps County, Missouri

On June 24, 1974, I revisited Bray's lake site with Warren Dean. The purpose of the visit was to examine the layout of the proposed lagoon sites. While there, I brought up the subject of Mr. Dean diverting the leak on the west side of the dam so that leakage water will enter the stream. Also, I suggested that he build a weir so that leakage from the dam could be measured and furnish a list of companies who do grouting work on dams.

John W. Whitfield
John W. Whitfield, Geologist
Applied Engineering & Urban Geology
Missouri Geological Survey
June 27, 1974

FOR FILE ONLY

BRAYS LAKE RECONNAISSANCE

PHELPS COUNTY

On April 12, 1979, a reconnaissance was made on the Brays lake site, after 3 to 4 inches of rain had fallen the previous day. The local radio had announced that there was a possibility of Brays lake going out. In addition, the Engineering Geology Section had received a phone call from a local radio station asking about the condition of Brays lake.

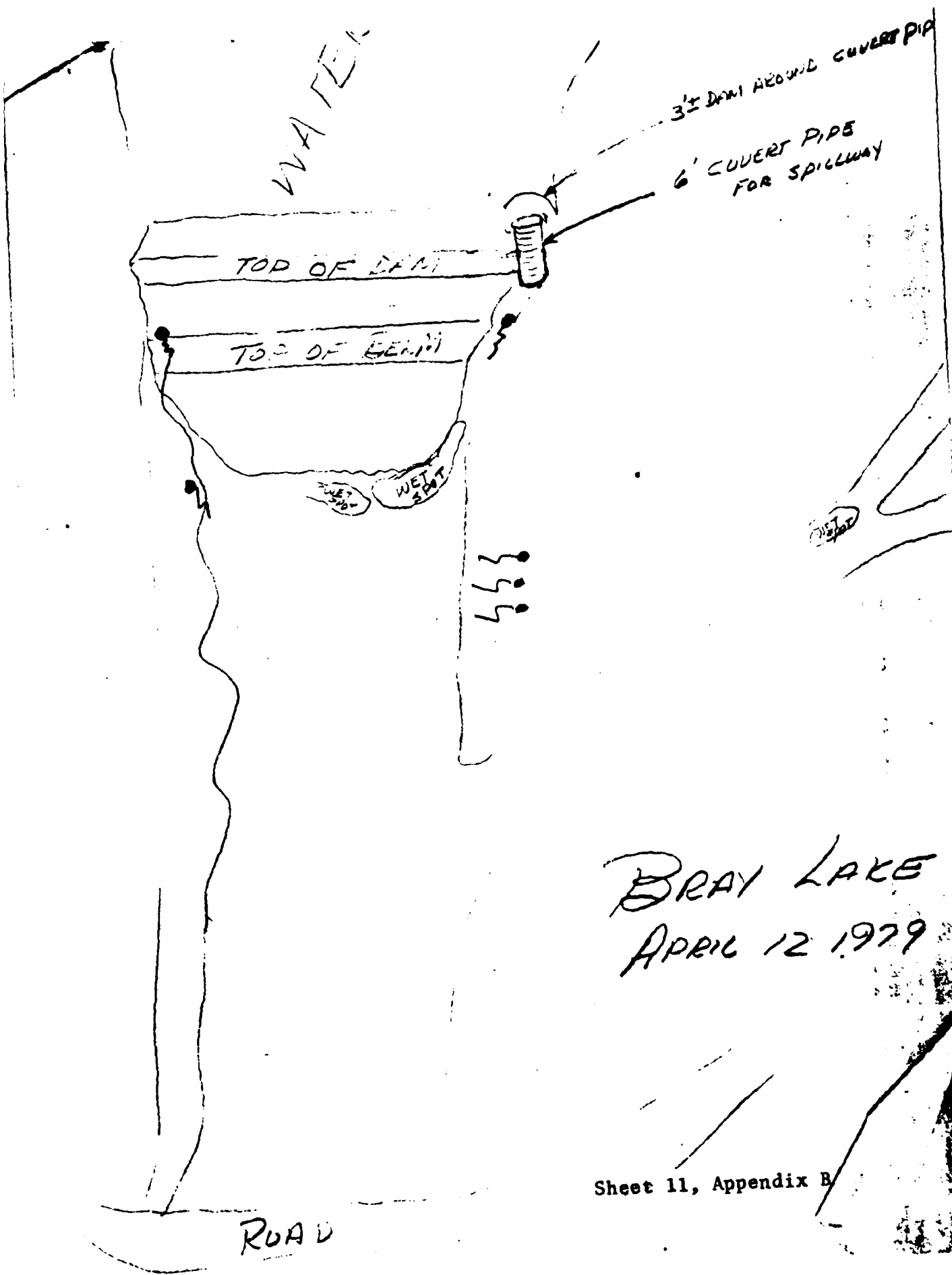
At 9 a.m., I drove out to the lake and walked over the dam. The water level was approximately 12 feet below the top of the dam. The water level was about the level of the spillway. It is difficult to judge the exact level between the spillway and the lake water level because there was a small levee around the 6 foot diameter corrugated pipe that served as the spillway on the east side of the dam. The water will have to raise about 3 more feet before it would go over the small levee and then drain out the spillway.

There were leaks on each abutment of the dam but these leaks had been noted before. No measurements were made on the water coming out of leaks but the amount did not seem unusually high.

The dam appeared to be sound. There were no slides or indications of surface failure on the dam. There were ruts on the downstream slope that had been caused by cars or motorcycles driving up the face of the dam.

There were a series of leaks downstream of the east abutment that had not been seen before. Estimated amount of leakage was 50 gpm.

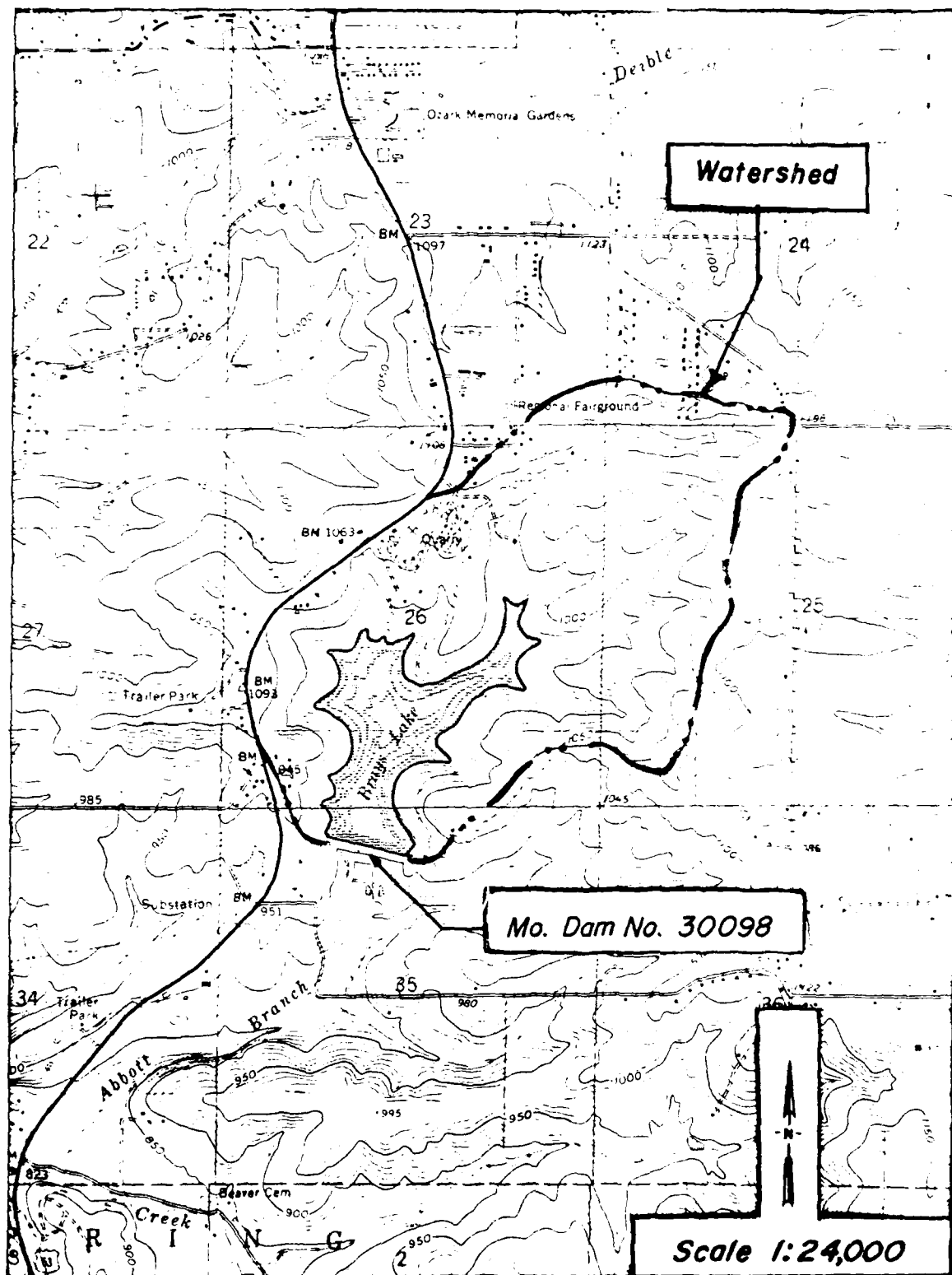
John W. Whitfield, Geologist
Engineering Geology Section
Geology & Land Survey
April 13, 1979



BRAY LAKE
APRIL 12 1979

APPENDIX C

From Rolla 7.5' Quad



LAKE AND WATERSHED MAP

Sheet 1 Appendix C

HYDRAULIC AND HYDROLOGIC DATA

Design Data: From Field Measurements and Computations

Experience Data: No records are available. Mr. Bray reported that despite the absence of a spillway when he owned the dam (1963 to 1974), the embankment was never overtopped. Mr. Dean indicated that the 8 in. plastic pipe, which discharges into the sewer line, has operated once, when the lake level was about 6 in. above the pipe invert. The 8 in. diameter clay pipe and 78 in. diameter CMP have reportedly never operated.

Visual Inspection: At the time of the inspection, the pool level was approximately 0.95 ft below normal pool.

Overtopping Potential: Flood routings were performed to determine the overtopping potential. The watershed and the reservoir surface areas were obtained by planimeter from the U.S.G.S. Rolla, Missouri 7.5 minute quadrangle map. The storage volume was developed from these data. A 5 minute interval unit graph was developed for this watershed, which resulted in a peak inflow of 2075 c.f.s. and a time to peak of 15 minutes. Application of the probable maximum precipitation minus losses results in a flood hydrograph peak inflow of 12,248 c.f.s. Rainfall distribution for the 24 hour storm was according to EM 1110-2-1411.

Based on our analyses, the spillway will pass 57 percent of the Probable Maximum Flood (PMF). The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that the structure (intermediate size with high downstream hazard potential) pass the PMF, without overtopping.

The routing of the PMF through the spillway and dam indicates that the dam will be overtopped by 2.53 ft at elevation 965.73. The duration of the overtopping will be 9.33 hours, and the maximum outflow will be 2721 c.f.s. The maximum discharge capacity of the spillway is 360 c.f.s. Analysis of the data indicates that the 100-year frequency flood will not overtop the dam. The computer input, output and hydrograph for the PMF are presented on Sheets 5, 6 and 7 of Appendix C.

OVERTOPPING ANALYSIS FOR BRAY LAKE DAM

INPUT PARAMETERS

1. Unit Hydrograph - SCS Dimensionless - Flood Hydrograph Package (HEC-1); Dam Safety Version Was Used.
Hydraulic Inputs Are As Follows:
 - a. Twenty-four Hour Rainfall of 26.2 Inches
For 200 Square Miles - All Season Envelope
 - b. Drainage Area = 686 Acres; = 1.07 Sq. Miles
 - c. Travel Time of Runoff 0.35 Hrs.; Lag Time 0.21 Hrs.
 - d. Soil Conservation Service Soil Group C
 - e. Soil Conservation Service Runoff Curve No. 85 (AMC III)
0 (AMC II)
 - f. Proportion of Drainage Basin Impervious 0.15
2. Spillways
 - a. Primary Spillway: 78 in. I.D. CMP, Length = 60 ft;
Inlet invert El. 952.6; Invert outlet El. 951.2
 - b. Emergency Spillway: None
Length - Ft.; Side Slopes -; C = -
 - c. Dam Overflow
Length 1160 Ft.; Crest El. 963.2; C = Varies
3. Spillway and Dam Rating:
Curve Prepared by Hanson Engineers. Data Provided
To Computer on Y4 and Y5 Cards. (see Sheet 5, Appendix C)
Formula Used:
 - a) Primary Spillway: chart for CMP with entrance control
 - b) DAM: $\frac{Q^2}{g} = \frac{A^3}{T}$ (Using \$L and \$V Cards)

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

SUMMARY OF DAM SAFETY ANALYSIS

1. Unit Hydrograph
 - a. Peak - 2075 c.f.s.
 - b. Time to Peak 15 Min.
2. Flood Routings Were Computed by the Modified Puls Method
 - a. Peak Inflow
50% PMF 6,124 c.f.s.; 100% PMF 12,248 c.f.s.
 - b. Peak Elevation
50% PMF 962.34 100% PMF 965.73
 - c. Portion of PMF That Will Reach Top of Dam
57 %; Top of Dam Elev. 963.2 Ft.
3. Computer Input and Output Data are shown on Sheets 5 and 6 of this Appendix.

A OVERTOPPING ANALYSIS FOR BRAYS LAKE DAM (# 20)
 A STATE ID NO. 30098 CO. NO. 161 CO. NAME PHELPS
 A HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 79511
 B 300 5
 B1 5
 J 1 8 1
 J1 .10 .20 .30 .50 .60 .70 .80 1.0
 K 0 1 3 1
 K1 INFLOW HYDROGRAPH COMPUTATION **
 M 1 2 1.07 1.07 1 1
 P 0 26.2 102 120 130
 T -1 -85 0.15
 W2 0.35 0.21
 X 0 -.1 2
 K 1 2 0 4 1
 K1 RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE **
 Y 1 1
 Y1 1 2192 -1
 Y4 955.5 956 957.7 958 959 960 961 962 963.2 966
 Y5 0 1 4 25 210 260 300 330 360 430
 \$A 0 96 123 132 152
 \$E 887 955.5 960 963.2 970
 \$\$ 955.5
 \$D 963.2
 \$L 0 44 194 445 1012 1160 1180 1225 1270
 \$D 963.2 964 964.7 965.1 965.5 965.6 966 967 968
 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 | | | | | | |
| HYDROGRAPH AT | 1 | 1.07 | 1 | 1225. | 2450. | 3674. | 6124. | 7349. | 8574. | 9799. | 12248. | | | | | | |
| | (| 2.77) | (| 34.68) | (| 69.37) | (| 104.05) | (| 173.41) | (| 208.10) | (| 242.78) | (| 277.46) | (|
| ROUTED TO | 2 | 1.07 | 1 | 3. | 145. | 253. | 339. | 374. | 608. | 1300. | 2721. | | | | | | |
| | (| 2.77) | (| 0.09) | (| 4.10) | (| 7.15) | (| 9.59) | (| 10.59) | (| 17.22) | (| 36.81) | (|

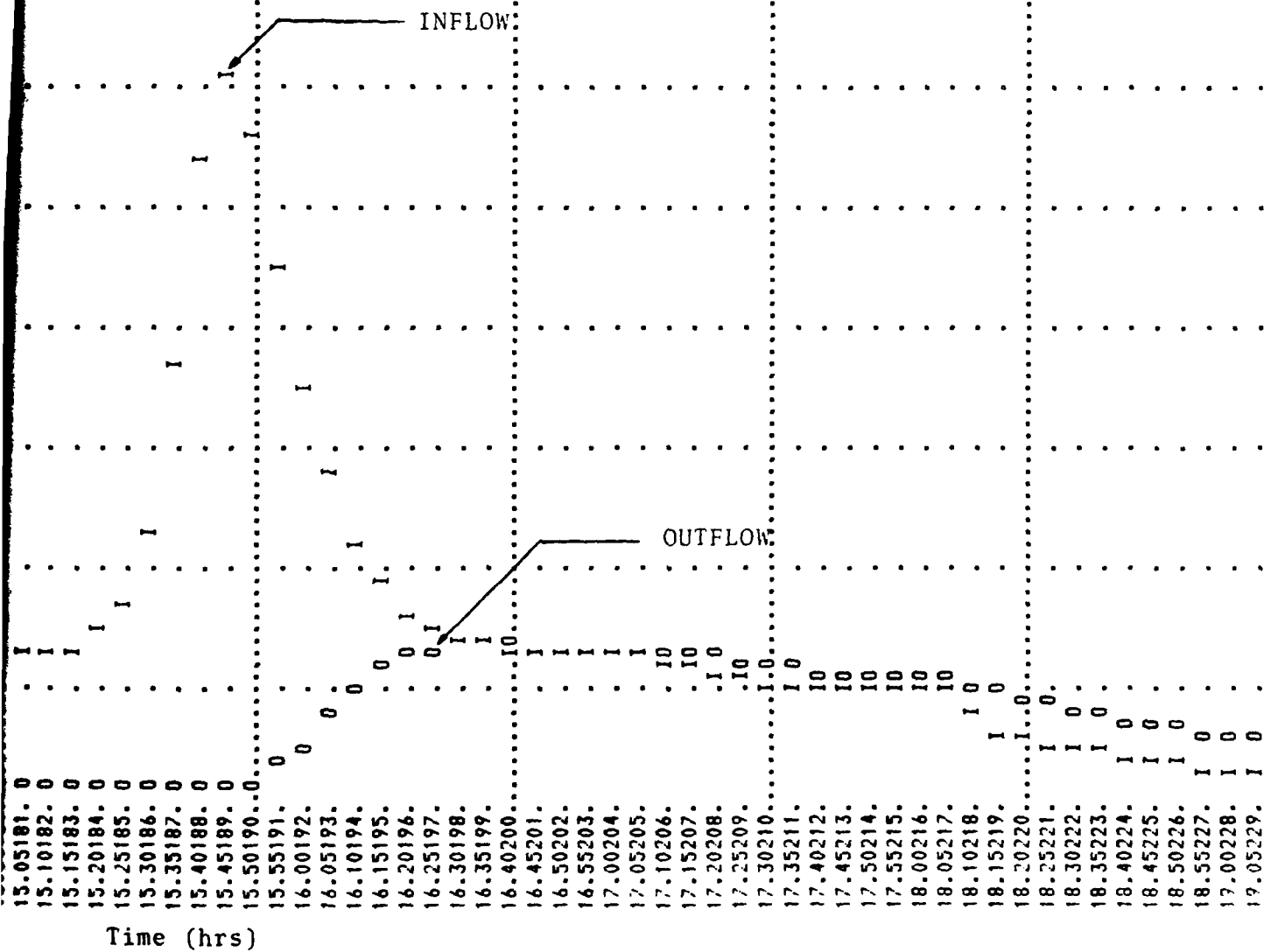
SUMMARY OF DAM SAFETY ANALYSIS

| PLAN 1 | | | | INITIAL VALUE | SPILLWAY CREST | TOP OF DAM |
|--------------|----------------------------|------------------------|-----------------------|---------------------|-------------------------|---------------------------|
| RATIO OF PMF | MAXIMUM RESERVOIR U.S.ELEV | MAXIMUM DEPTH OVER DAM | MAXIMUM STORAGE AC-FT | MAXIMUM OUTFLOW CFS | DURATION OVER TOP HOURS | TIME OF MAX OUTFLOW HOURS |
| | | | | | | |
| | | | | | | |
| 0.10 | 957.33 | 0.00 | 2378. | 3. | 0.00 | 25.00 |
| 0.20 | 958.65 | 0.00 | 2523. | 145. | 0.00 | 18.83 |
| 0.30 | 959.85 | 0.00 | 2665. | 253. | 0.00 | 18.67 |
| 0.50 | 962.34 | 0.00 | 2979. | 339. | 0.00 | 18.92 |
| 0.60 | 963.56 | 0.36 | 3140. | 374. | 4.25 | 19.00 |
| 0.70 | 964.62 | 1.42 | 3281. | 608. | 8.75 | 18.67 |
| 0.80 | 965.27 | 2.07 | 3370. | 1300. | 9.08 | 18.17 |
| 1.00 | 965.73 | 2.53 | 3435. | 2721. | 9.33 | 16.58 |

| | Discharge (c.f.s.) |
|-----------------------|--------------------|
| 11.401400..I..... | |
| 11.451410 I..... | |
| 11.501420 I..... | |
| 11.551430 I..... | |
| 12.001440 I..... | |
| 12.051450 I..... | |
| 12.101460 I..... | |
| 12.151470 I..... | |
| 12.201480 I..... | |
| 12.251490 I..... | |
| 12.301500.....I..... | |
| 12.351510 I..... | |
| 12.401520 I..... | |
| 12.45153.0 I..... | |
| 12.50154.0 I..... | |
| 12.55155.0 I..... | |
| 13.00156.0 I..... | |
| 13.05157.0 I..... | |
| 13.10158.0 I..... | |
| 13.15159.0 I..... | |
| 13.20160.0.....I..... | |
| 13.25161.0 I..... | |
| 13.30162.0 .I..... | |
| 13.35163.0 .I..... | |
| 13.40164.0 .I..... | |
| 13.45165.0 .I..... | |
| 13.50166.0 .I..... | |
| 13.55167.0 .I..... | |
| 14.00168.0 .I..... | |
| 14.05169.0 .I..... | |
| 14.10170.0.....I..... | |
| 14.15171.0 I..... | |
| 14.20172.0 I..... | |
| 14.25173.0 I..... | |
| 14.30174.0 I..... | |
| 14.35175.0 I..... | |
| 14.40176.0 I..... | |
| 14.45177.0 I..... | |
| 14.50178.0 I..... | |
| 14.55179.0 I..... | |
| 15.00180.0.....I..... | |
| 15.05181.0 I..... | |
| 15.10182.0 I..... | |
| 15.15183.0 I..... | |
| 15.20184.0 I..... | |
| 15.25185.0 I..... | |

INFLOW-OUTFLOW
HYDROGRAPH
FOR 100% P.M.F.

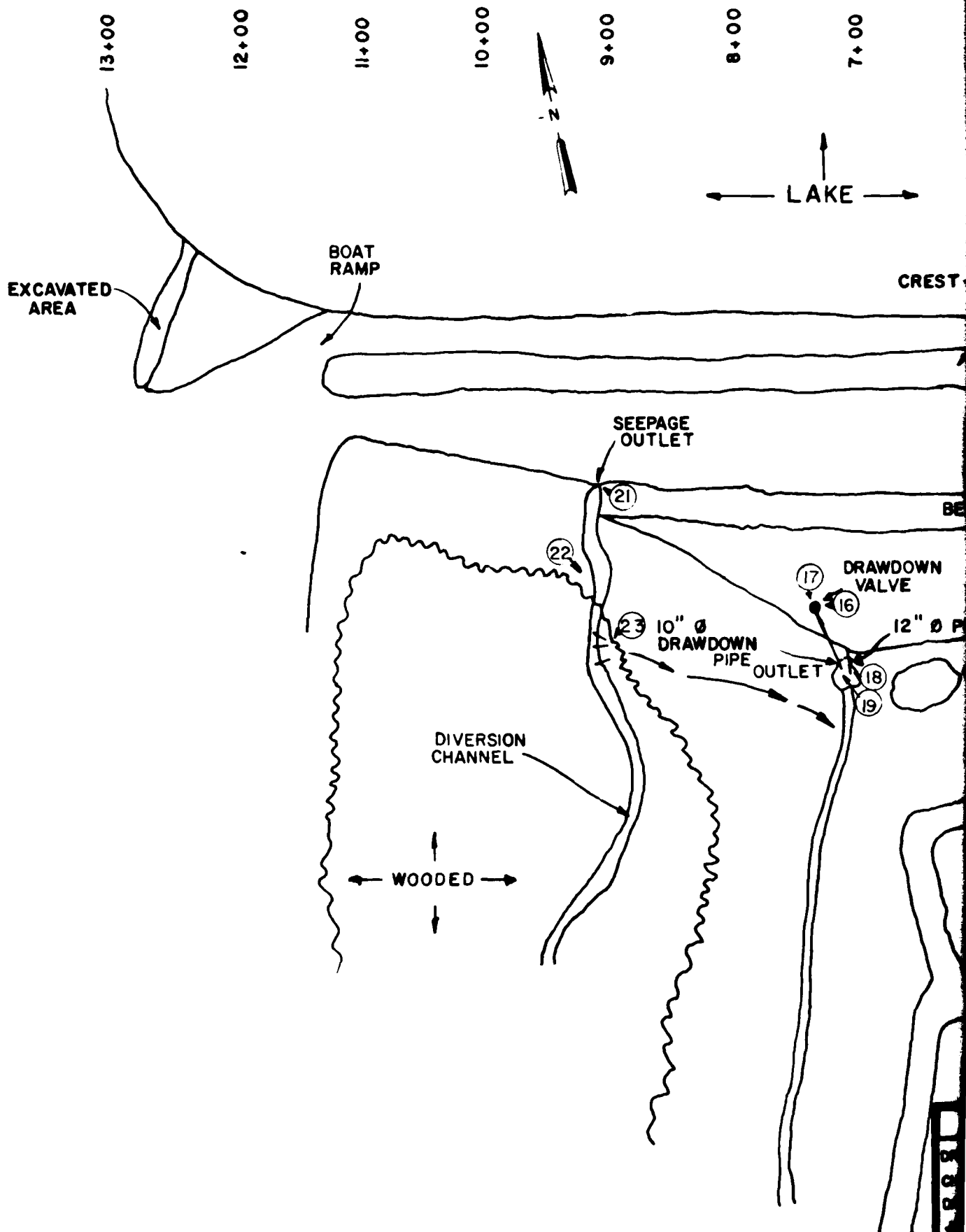
Max. Inflow = 12,248 c.f.s.
Max. Outflow = 2721 c.f.s.



APPENDIX D

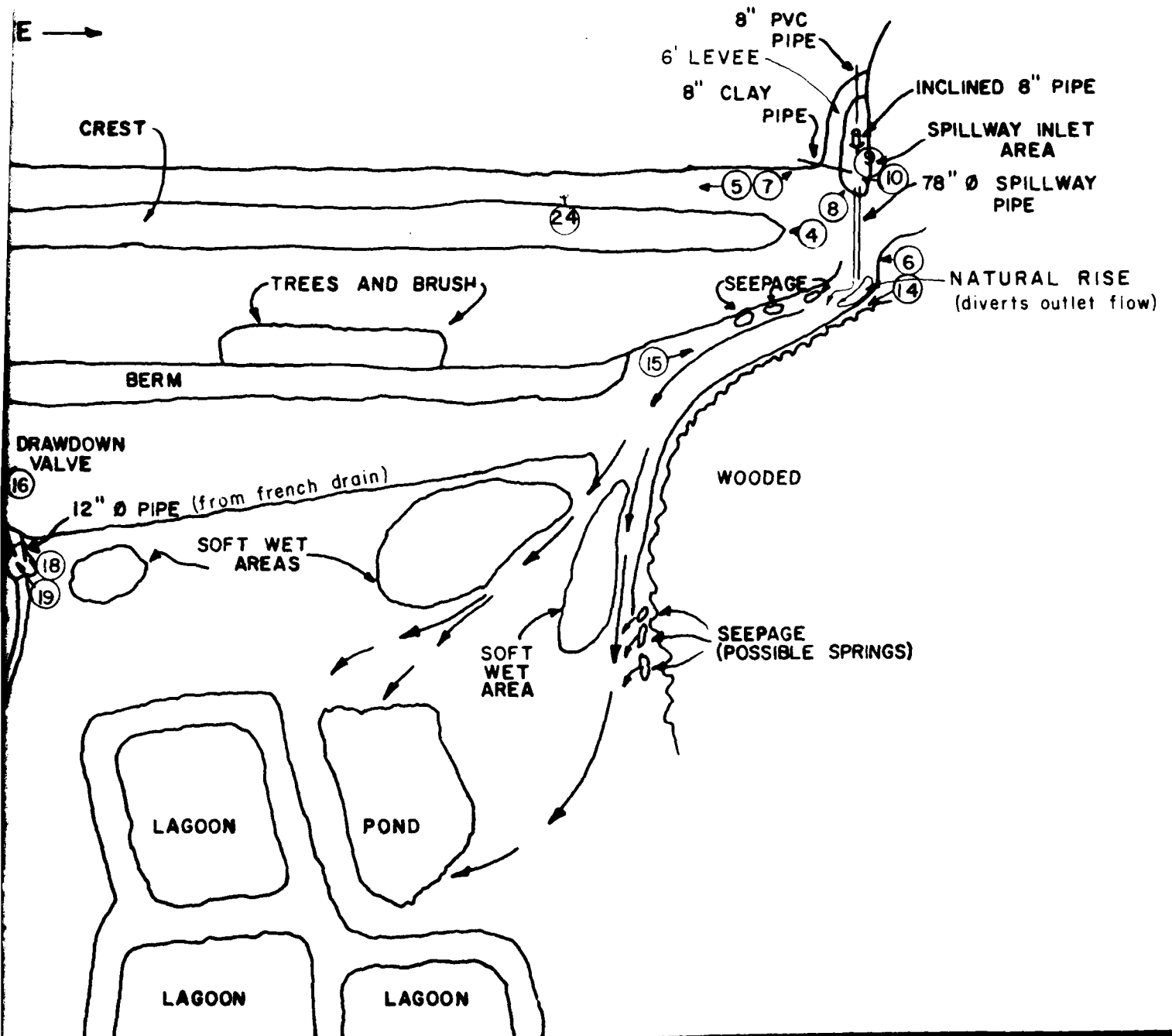
INDEX TO PHOTOGRAPHS

| <u>Photo No.</u> | <u>Description</u> |
|------------------|---|
| 1 | Aerial - Lake and Dam, Looking Northeast |
| 2 | Aerial - Dam and Downstream Area, Looking Southeast |
| 3 | Aerial - Dam, Looking West |
| 4 | Crest of Dam, Looking West |
| 5 | Upstream Face of Dam, Looking West |
| 6 | Downstream Face of Dam, Looking West |
| 7 | Cofferdam Around Spillway Inlet Area, Looking Northeast |
| 8 | Spillway Inlet Area, Looking Upstream |
| 9 | PVC Pipe Outlet (Into Spillway Inlet Area) |
| 10 | VCP Outlet (Into Spillway Inlet Area) |
| 11 | Spillway Pipe Inlet |
| 12 | Spillway Pipe Outlet |
| 13 | Spillway Outlet and Discharge Area |
| 14 | Spillway Discharge Channel, Looking Downstream |
| 15 | Spillway Discharge Channel, Looking Upstream |
| 16 | Drawdown Pipe Valve Enclosure |
| 17 | Drawdown Pipe Valve |
| 18 | Drawdown Pipe Outlet |
| 19 | 12 in. Diameter Steel Pipe to Drain Spring |
| 20 | Typical Animal Burrow on Downstream Embankment Face |
| 21 | Exit of Seepage from Downstream Face |
| 22 | Channel to Divert Seepage from Embankment Face |
| 23 | Pipes Carrying Seepage Water from Diversion Channel Looking Downstream |
| 24 | View of Lake and Watershed Area |



7+00 6+00 5+00 4+00 3+00 2+00 1+00 0+00

E →



PLAN SKETCH

DRAWN _____
 CHECKED _____
 DATE _____
 JOB NO. _____



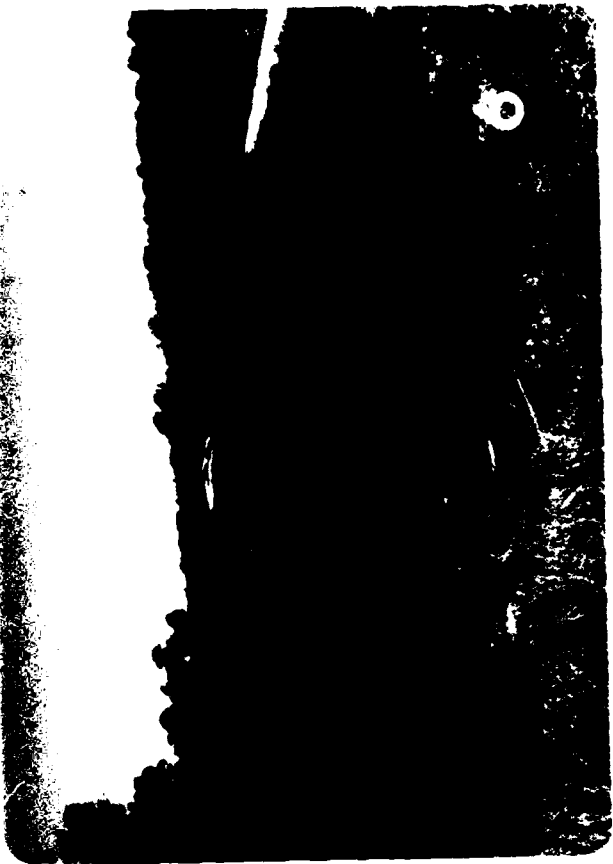
SPRINGFIELD, ILL.

PEORIA, ILL.

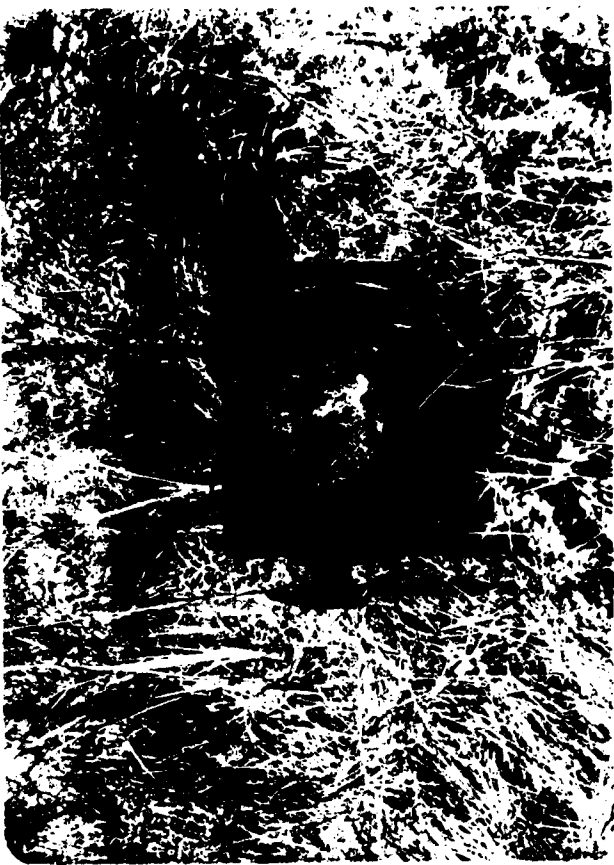
BRAY LAKE DAM
 MO. I.D. NO. 30098

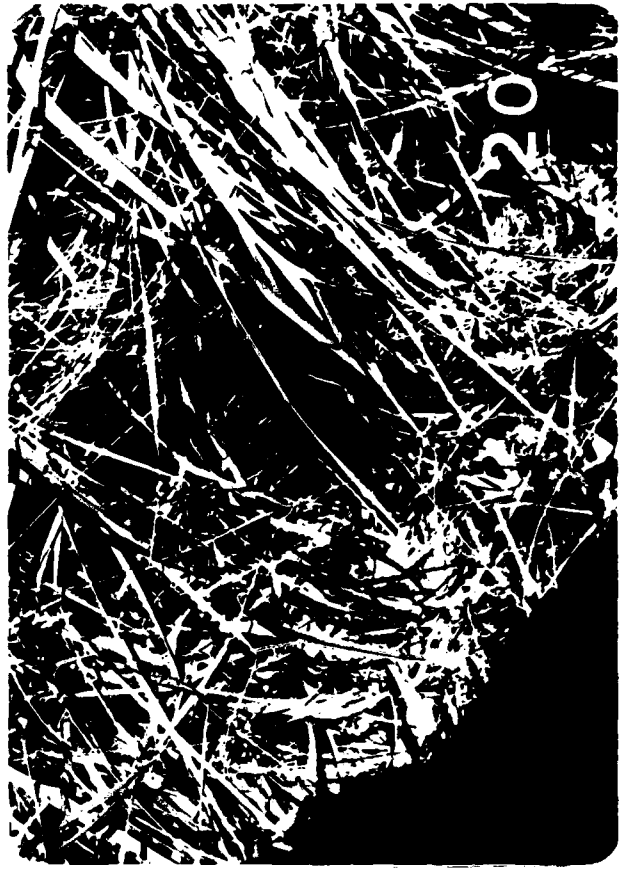
SHEET 2 APPENDIX D

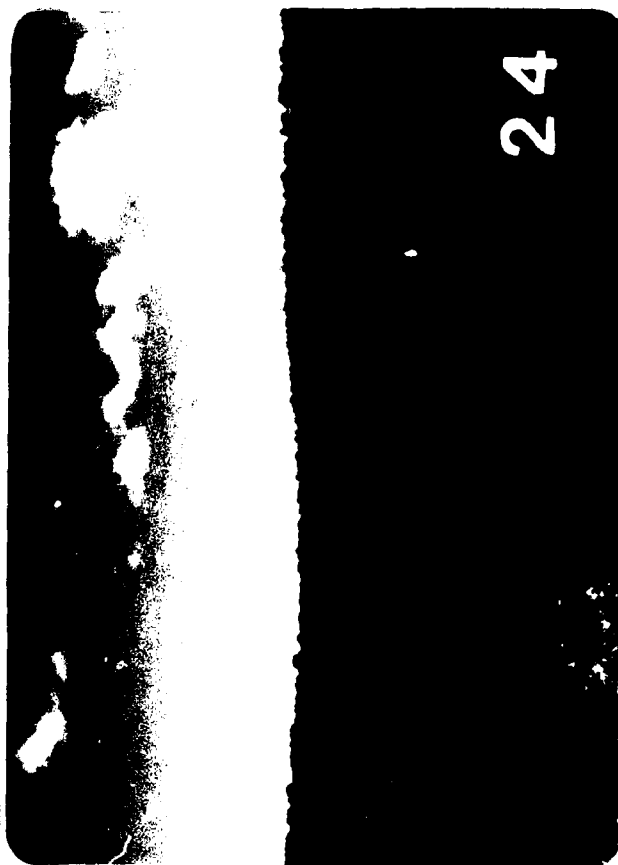












DATE
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