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NATIONAL DAM SAFETY PROGRAM. LAKE WINNEBAGO DAM (MO 20312), MIS--ETC(U)
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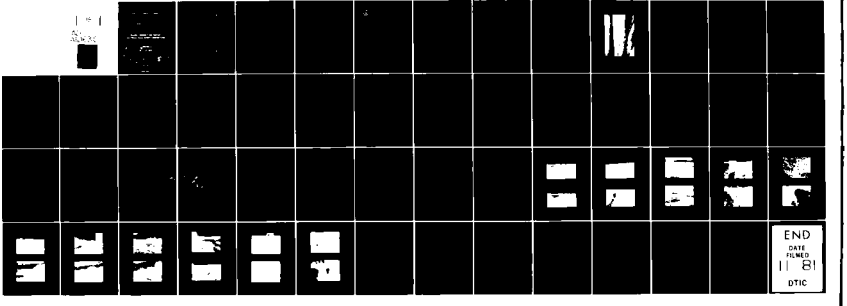

MISSOURI-KANSAS CITY BASIN

AD A106312

LAKE WINNEBAGO DAM

CASS COUNTY, MISSOURI

MO 20012

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

DTIC FILE COPY

St. Louis District

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

FOR: STATE OF MISSOURI

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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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MISSOURI-KANSAS CITY BASIN

LAKE WINNEBAGO DAM

CASS COUNTY, MISSOURI

MO 20312

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

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

MAY 1979

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

IN REPLY REFER TO

SUBJECT: Lake Winnebago Dam, Mo. ID No. 20312
Phase I Inspection Report

This report presents the results of field investigation and evaluation of the Lake Winnebago 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:

1) Spillway will not pass 50 percent of the Probable Maximum Flood
2) Overtopping could result in dam failure
3) Dam failure significantly increases the hazard to loss of life downstream

SUBMITTED BY: SIGNED — Chief, Engineering Division — 14 MAR 1980 — Date

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

LAKE WINNEBAGO

CASS COUNTY, MISSOURI

MISSOURI INVENTORY NO. 20312

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF

ST. LOUIS DISTRICT CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

MAY 1979

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Lake Winnebago Dam
State Located	Missouri
County Located	Cass County
Stream	Middle Big Creek
Date of Inspection	24 May 1979

Lake Winnebago Dam was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. 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 developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as an intermediate size dam with a high downstream hazard potential. For the Lake Winnebago Dam, the estimated length of the damage zone extends approximately twenty miles downstream of the dam. Within the damage zone are many homes and three buildings.

Our inspection and evaluation indicates 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 not pass either the probable maximum flood or 50 percent of the probable maximum flood without overtopping but will pass 25 percent of the probable maximum flood. The spillway will pass the 100-year flood. Based on the size of dam and downstream hazard potential, the spillway should be capable of passing the PMF without overtopping the dam. 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.

Deficiencies visually observed by the inspection team were areas of minor surface erosion, some minor displacement of the riprap, and seepage.

There were no observed deficiencies or conditions existing at the time of the inspection which indicate an immediate safety hazard. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. In addition, detailed seepage and stability analyses of the existing dam, as required by the guidelines, should be performed. A detailed report discussing each of these deficiencies is attached.

V

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Harry L. Callahan, Partner
Black & Veatch

OVERVIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
LAKE WINNEBAGO DAM

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

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

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 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, in "Recommended Guidelines for Safety Inspection of Dams". 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.

(1) The dam is an earth structure approximately 1,200 feet in length located in the valley of Middle Big Creek approximately 1-1/2 miles south of the Jackson and Cass County line in north central Cass County (Plate 1). The crest width is 30 feet and has an unpaved road along its length. The upstream slope is covered with riprap and the downstream slope has a cover of grass and rock. Topography of the contributing watershed is characterized by rolling hills. Topography in the vicinity of the dam is shown in Plate 2.

(2) The emergency spillway is located in the left abutment. The emergency spillway is a cut in natural rock such that the walls are nearly vertical, the floor flat, and both are composed of limestone. A 2-foot wide concrete sill lies across the emergency spillway near the upstream end. Discharge through the emergency spillway overflows into the natural channel below the dam. The slope from the lower end of the spillway's rock cut to the natural channel is very steep.

(3) A 24-inch steel drain pipe with gate valve runs under the embankment and is located about 200 feet west of the dam's east abutment. Its primary function is to draw down the lake if necessary. Access to the gate valve is through a five-foot diameter concrete control tower located on the upstream dam slope at about the water line. Discharge

from the pipe goes to a riprapped channel which conveys water to the natural channel.

(4) During the period of time Lake Winnebago was drained for repair and reconstruction (see Section 1, paragraph 1.2g and Section 6, paragraph 6.1d for details of the post construction work), a sewerline was placed in the lake bed. A 36" steel pipe was run through the dam near the right abutment. An access manhole is located on the upstream dam slope at about the waterline.

(5) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in north central Cass County, Missouri, as indicated on Plate 1. The lake formed by the dam is shown on the United States Geological Survey 7.5 minute series quadrangle map for Pleasant Hill, Missouri in Sections 4, 5 and 9 of T46N, R31W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the intermediate size category.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The Lake Winnebago Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For the Lake Winnebago Dam, the estimated length of the damage zone extends approximately twenty miles downstream of the dam. Within the damage zone are many homes and three buildings.

e. Ownership. The dam is owned by the Lake Winnebago Development Company, Inc. However, this corporation has been involved in reorganization proceedings under Chapter 10 of the Bankruptcy Act since the fall of 1970. Dale M. Thompson is the court-appointed trustee for this company and his office is in the United Missouri Bank building, 10th and Grand, Kansas City, Missouri. During the past ten years problems with the dam have been handled by the Lake Winnebago Homeowners Association.

f. Purpose of Dam. The dam forms a 315-acre residential development and recreation lake.

g. Design and Construction History. The original design of the dam was by Tibbits-Young, Consulting Engineers, 1519 Sunshine, Springfield, Missouri. This design work was apparently initiated early in 1964 and the final plans were dated April 6, 1964. Tibbits-Young has been reorganized and is now Tibbits-Nachtrab, 1640 St. Louis, Springfield, Missouri 65802. Data relating to the original construction were not available.

However, an October 31, 1965 newspaper article states that the spillway was under construction and the lake was filled to within ten feet of the normal pool. On February 15, 1972 a sink hole was first noticed on the upstream face of the dam in the vicinity of the outlet pipes. On or about August 9, 1973 the Lake Winnebago Home Owners Association hired R.J. Spiegel, P.E., now deceased, as engineer for the repair and reconstruction of Lake Winnebago Dam. The repair and reconstruction work was completed by a "Contractor per task" procedure under the direction of R.J. Spiegel, PE. Data relating to the design of the reconstruction were not available. Weekly summaries of daily construction records were available for the dam reconstruction.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, evaporation, and capacity of the uncontrolled spillway all combine to maintain a relatively stable water surface elevation. The gate valve on the drain outlet is operated annually to determine if it is functioning properly.

1.4 PERTINENT DATA

a. Drainage Area - 19.98 square miles.

b. Discharge at Damsite.

(1) Normal discharge at the damsite is through an uncontrolled spillway.

(2) Estimated experienced maximum flood at damsite - Unknown.

(3) Estimated ungated spillway capacity at maximum pool elevation - 29,150 cfs (Probable Maximum Flood Pool El.929.9).

c. Elevation (Feet Above M.S.L.).

(1) Minimum top of dam - 924.7 ± (see Plate 3)

(2) Minimum spillway crest - 918.1 ± (see Plate 5)

(3) Streambed at centerline of dam - 861.2 ±

(4) Maximum tailwater - Unknown.

d. Reservoir.

(1) Length of maximum pool - 12,000 feet ±

(2) Length of normal pool - 10,100 feet ±

e. Storage (Acre-feet).

(1) Top of dam - 7,150

(2) Emergency spillway crest - 4,670

(3) Design surcharge - Not available.

f. Reservoir Surface (Acres).

(1) Top of dam - 390

(2) Emergency spillway crest - 315

g. Dam.

(1) Type - Earth embankment

(2) Length - 1,200 ± feet

(3) Height - 64 feet ±

(4) Top width - 30 feet

(5) Side slopes - Varies (see Plate 4).

(6) Zoning - Dam is composed of three zones. The upstream and downstream zones are brown clay and the central impervious zone is red clay. The material was locally available. The material descriptions are as shown on the design drawings. The material origins are not known.

(7) Impervious core - The dam has an impervious red clay core which is 30 feet wide at the top and 100 feet wide at the bottom.

(8) Cutoff - The bottom of the clay core forms a cutoff into the foundation rock.

(9) Grout curtain - None.

(10) Internal drainage system - Horizontal sand blanket.

h. Diversion and Regulating Tunnel - None.

i. Spillway.

(1) Type - Rock cut open channel.

(2) Width of spillway - 330 feet.

(3) Crest elevation - 918.1 feet m.s.l. (see Plate 5).

(4) Gates - None.

(5) Upstream channel - Rock cut in natural limestone.

(6) Downstream channel - Rock cut in natural limestone with abrupt drop through rock rubble to natural channel.

j. Outlet Works. A 24-inch steel drain pipe lies under the embankment about 200 feet west of the dam's east abutment. Discharge through the pipe is regulated by a gate value. Downstream from the pipe, a riprapped channel carries the water to the natural channel.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Little design data were available for the original construction. The following are the items included in the Lake Winnebago Dam folder. A report titled "Specifications - Lake Winnebago Dam, Lake Winnebago Development Co. Inc., Tibbits - Young, Consulting Engineers, April 6, 1964." Included in this report were the results of soil tests by the General Testing Laboratories, 1517 Walnut St., Kansas City, Missouri. There are calculations on determining peak runoff, stream flow and flood routing, and cross sections of the natural stream channel. There is a file on quantity and cost estimates and one on specifications.

No design data were available on the dam reconstruction. A complete set of specifications for the reconstruction, prepared by R.J. Spiegel, PE, now deceased, was available. Design drawings were obtained for the original construction of Lake Winnebago Dam, the reconstruction, and the sewer line.

2.2 CONSTRUCTION

No records were available on the original construction. However, the dam was apparently completed in the fall of 1965. Weekly summaries of daily construction records were available for the dam reconstruction.

2.3 OPERATION

No operation records were available.

2.4 GEOLOGY

The dam is located across a broad shallow valley formed in shale and limestone of the Pleasanton and Kansas City Groups of the Pennsylvanian System. The design drawings indicate that the abutments of the dam are in the Swope, Ladore, and Hertha formations of the Kansas City Group and the Upper Unnamed formation of the Pleasanton Group and that the foundation of the dam is in the Upper Unnamed formation of the Pleasanton Group. The Swope and Hertha formations are predominantly limestone with several thin shale units, and the Ladore and Upper Unnamed formations are shale. No sinks were observed in the limestone units.

The soils of the reservoir and dam area consist of the Blackoar-Zook and Polo-Sogn soil associations. The Blackoar-Zook soil association is an alluvial soil developed along the stream course. The surface soil is black to gray and the subsoil is gray, brown, and yellow. The Polo-Sogn soil association is developed from loess over shales or limestones. The surface soil is dark gray to dark brown. The subsurface

soil is red below 3 feet of depth. The design drawings indicate that the soil in the valley consists of brown to gray silty clay with some sand of probable alluvial origin. For engineering purposes the soils in the reservoir and dam area are classified as CL according to published literature.

2.5 EVALUATION

a. Availability. Data that were available are described in 2.1.

b. Adequacy. The engineering data that were available were not adequate to make a detailed assessment of the design, construction, and operation. 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. The validity of the design, construction, and operation could not be determined due to the lack of engineering data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Lake Winnebago Dam was made on 24 May 1979. The inspection team included professional engineers with experience in dam design and construction, hydrology, hydraulic engineering, and geotechnical engineering. This dam appeared to be in good condition. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following items at the dam. In general, the embankment appeared to be in good condition. Maintenance of the dam was evident as all small trees had been cut. Slope protection on the front face of the dam consisted of riprap and grass. There was minor displacement and loss of riprap. The downstream slope is protected by grass and rock fill. Some erosion was observed where water accumulates on the bench between Station 1+00 and Station 3+00 (see Plate 3). The maximum width and depth of erosion was between 1.5 and 2 feet. Seepage was observed downstream of the dam and at the left and right abutments. All observed seepage was clear and was of a magnitude of less than 1 gpm. Seepage was suspected around the outlet works into the outlet channel. There was no evidence of animal burrows, sliding, cracking, settlement, sinkholes, rutting, or potholes. There is no need for re-vegetation.

c. Appurtenant Structures. The inspection team observed the following items pertaining to appurtenant structures. The emergency spillway consists of a channel cut in natural rock at the left abutment. The channel is 330 feet wide with nearly vertical walls and ends with an abrupt drop through rock rubble to the natural channel. There is evidence of erosion or undercutting of the limestone ledge at a 4:1 slope at the end of this channel. Otherwise the walls and floor of the channel are in good condition. The outlet conduit consists of a 24-inch steel pipe with a gate valve. The gate valve is operated annually to assure proper function. Access to the gate valve is through a five foot diameter concrete control tower with a cover and lock. The drain pipe was observable through the control tower and about 20 feet of the downstream inside of the pipe was observed. The pipe appeared to be in good condition with no apparent distortion. The drain pipe discharges into a channel which discharges into the natural channel. This constructed channel is riprapped and in good condition.

d. Geology. A visual inspection of the geology and soils in the immediate vicinity of the dam confirmed the data shown on the design drawings that could be checked without subsurface investigation. The spillway is cut into the Bethany Falls limestone, Hushpuckney shale and Middle Creek limestone members of the Swope formation. The discharge

channel from the end of the spillway is in the upper unnamed shale formation of the Pleasanton Group. It is anticipated that the foundation is also in this unit. The abutments of the dam are in the Swope, Ladore, Hertha and Upper Unnamed formations of the Kansas City and Pleasanton Groups. The embankment consists of CL material as classified in the field from a near surface sample. The soils in the area around the dam are silty clay residual soils (CL) on the hills and slopes and alluvial silty clay along the discharge channel downstream of the dam. Some areas of rock outcrop are void of soil, and in other areas the shale is severely weathered to a silty clay when exposed at the surface.

e. Reservoir Area. No slides or excessive erosion due to wave action were observed along the shore of the reservoir.

f. Downstream Channel. The natural channel downstream from the primary spillway consists of a gravel streambed. Some outcropping of shale and limestone is visible along the banks. The stream banks are covered with brush and trees.

3.2 EVALUATION

The riprap should be maintained on the upstream slope in order to remain adequate. Cutting of the grass and brush on the embankment should be continued. The seepage does not appear likely to become a problem. The erosion may be a problem in the future. Both the seepage and the erosion should be monitored regularly.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is normally controlled by rainfall, runoff, evaporation, and capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM

There is no regularly scheduled program for maintenance. Grass and brush on the embankment are cut periodically as needed. The dam is inspected periodically by a committee of the Homeowners Associaton.

4.3 MAINTENANCE OF OPERATING FACILITIES

The drain gate valve is operated annually.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no existing system or preplanned scheme for warning occupants of the hazard zone below this dam.

4.5 EVALUATION

Some areas of minor erosion, seepage and displacement of riprap exist on the embankment. If these deficiencies are unchecked, they could lead to deterioration of the dam embankment.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data pertaining to hydrology and hydraulics were limited in scope and were performed prior to the construction of Raintree Lake upstream of Lake Winnebago. Independent calculations were performed for the report in accordance with the referenced guidelines.

b. Experience Data. The drainage area and lake surface area are developed from USGS Pleasant Hill and Raymore Quadrangle Maps. The spillway and dam layouts are from surveys made during the inspection and available drawings of the original plans and spillway reconstruction.

c. Visual Observations.

(1) The spillway is located in the left abutment and is in good condition. There is some undercutting of the rock ledge at the point where the spillway channel drops sharply to the natural stream channel.

(2) The 24-inch outlet pipe can be used to draw down the pool. The valve to the pipe is operated annually and appears to be in good condition.

(3) Spillway discharges are not anticipated to endanger the integrity of the dam.

d. Overtopping Potential. The spillway will not pass 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 spillway will pass 25 percent of the probable maximum flood without overtopping. The spillway will also pass the 100-year flood estimated to be 6,175 cfs developed by a 24 hour, 100-year rainfall. The rainfall distribution for the 100-year frequency storm was supplied by the St. Louis District, Corps of Engineers. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of intermediate size should pass the probable maximum flood. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 37,250 cfs. The remaining 29,150 cfs of the total discharge from the reservoir of 66,400 cfs passes through the emergency spillway. The estimated duration of overtopping is 8.2 hours at a maximum depth of 5.2 feet over the dam. The portion of the estimated peak discharge of 1/2 of the probable maximum flood overtopping the dam would be 10,120 cfs of the total discharge of the reservoir of 29,960 cfs. The remaining 19,840 cfs passes through the emergency spillway. The estimated duration of overtopping is 4.8 hours at a maximum depth of 2.3 feet over the

dam. Due to observed evidence of erodability of the embankment surface soils, it is anticipated that severe erosion and possible failure would occur as the result of prolonged overtopping of the dam. Failure of Raintree Lake upstream of Lake Winnebago would have a significant impact on the hydrologic or hydraulic analysis.

For the Lake Winnebago Dam, the estimated length of the damage zone extends approximately twenty miles downstream of the dam. Within the damage zone are many homes and three buildings.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

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

b. Design and Construction Data. No design data relating to the structural stability of the dam were found.

The dam was originally constructed as an earthfill dam and subsequently reinforced with the addition of rock across the entire downstream slope.

c. Operating Records. No operational records exist.

d. Post Construction Changes. Post construction changes included the installation of a sewer through the right abutment, and the reconstruction of the spillway and outlet works. The development of a two-phase reconstruction program was undertaken after several deficiencies were discovered in the integrity of the Winnebago Dam. The first phase involved the renovation of the outlet works. This work included the insertion of a 24-inch steel liner pipe into the existing east 30-inch C.M.P., grouting the space around the steel pipe, construction of the control tower, and grouting full the existing west 30-inch C.M.P. This portion of the work was completed in the spring of 1975. The sewer was installed in late 1975 during construction of the Middle Big Creek Interceptor Sewer for the Village of Lake Winnebago. The sewer was installed prior to the refilling of Lake Winnebago after the first phase of reconstruction. The second phase of reconstruction required the expansion of the existing spillway to accommodate anticipated flows. Rock excavated from the enlarged spillway area was placed across the entire downstream slope of the dam.

e. Seismic Stability. The dam is located in Seismic Zone 1 which is a zone of minor seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservatism should pose no serious stability problems during earthquakes in this zone.

Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available which is a deficiency. Therefore no inferences will be made regarding the seismic stability.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several items noted during the visual inspection by the inspection team that should be monitored or controlled are seepage, areas of minor erosion, and minor displacement of the riprap. 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.

b. Adequacy of Information. Due to the lack of engineering design data, the conclusions in this report were based only on performance history and visual conditions. The inspection team considers that these data are sufficient to support the conclusions herein. 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.

c. Urgency. A program should be developed as soon as possible to monitor at regular intervals the deficiencies described in this report. The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. The item recommended in paragraph 7.2a should be pursued on a high priority basis.

d. Necessity for Phase II. The Phase I investigation does not raise any serious questions relating to the safety of the dam or identify any serious dangers that would require a Phase II investigation.

e. Seismic Stability. This dam is located in Seismic Zone 1. Adequate description of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the stability analysis required by the guidelines.

7.2 REMEDIAL MEASURES

a. Alternatives. The present spillway has the capacity to pass 25 percent of the probable maximum flood without overtopping the dam. In order to pass the probable maximum flood as required by the Recommended Guidelines, the spillway should be modified to increase its capacity and/or the height of dam would need to be increased or the lake level would need to be lowered to increase storage capacity.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures are recommended:

(1) Erosion protection should be maintained on the upstream slope of the dam to prevent erosion of the embankment material due to wave action.

(2) Check the downstream face of the dam periodically for seepage and stability problems. If increased seepage flows are observed or sloughing on the downstream embankment slope is noted, the dam should immediately be inspected and the condition evaluated by an engineer experienced in design and construction of earthen dams.

(3) The grass cover of the embankment should be maintained and areas of minor surface erosion repaired and seeded as required to protect the embankment material.

(4) A detailed inspection of the dam should be made periodically by an engineer experienced in design and construction of dams. More frequent inspections may be required if additional deficiencies are observed or the severity of the reported deficiencies increases.

(5) Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of dams.

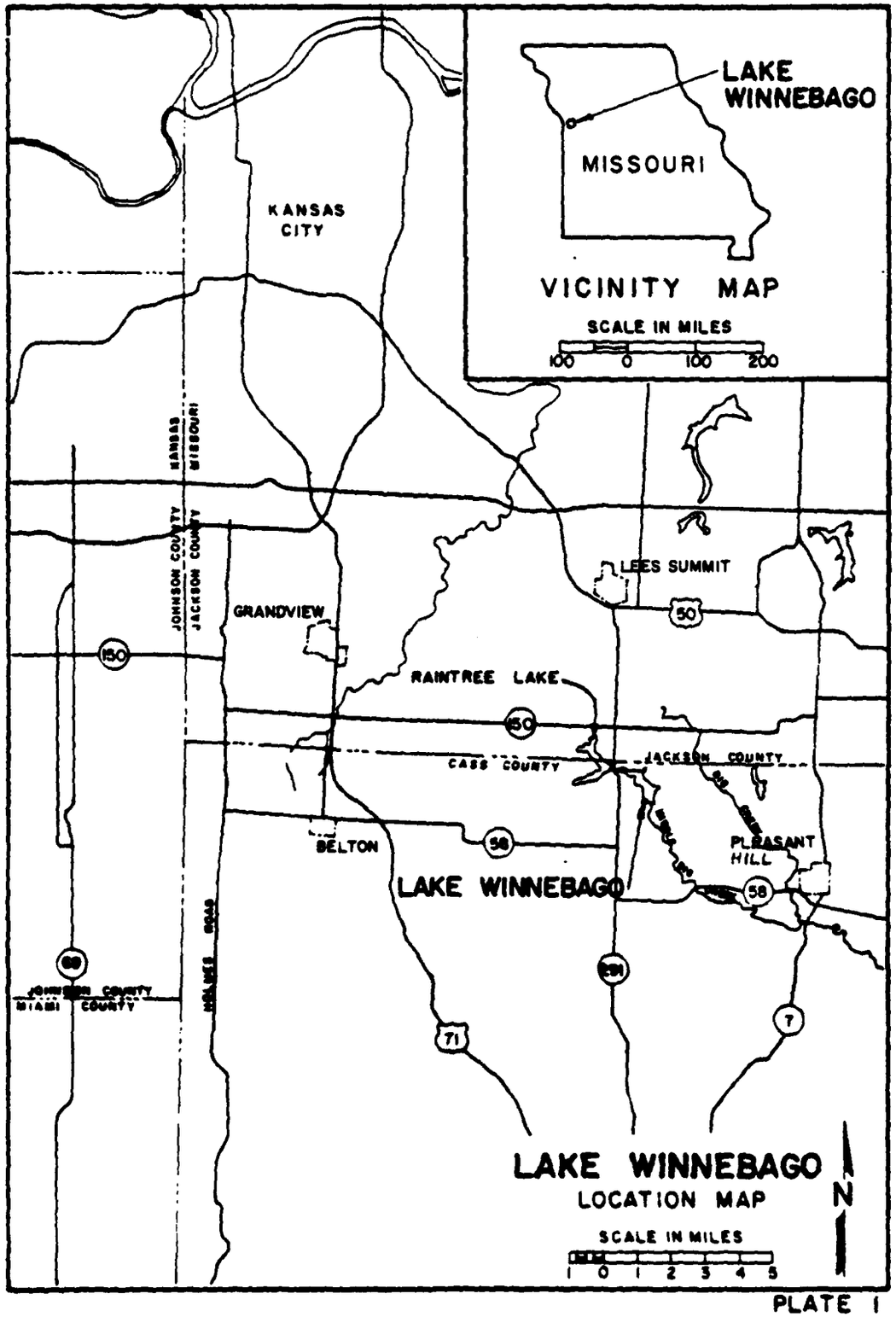
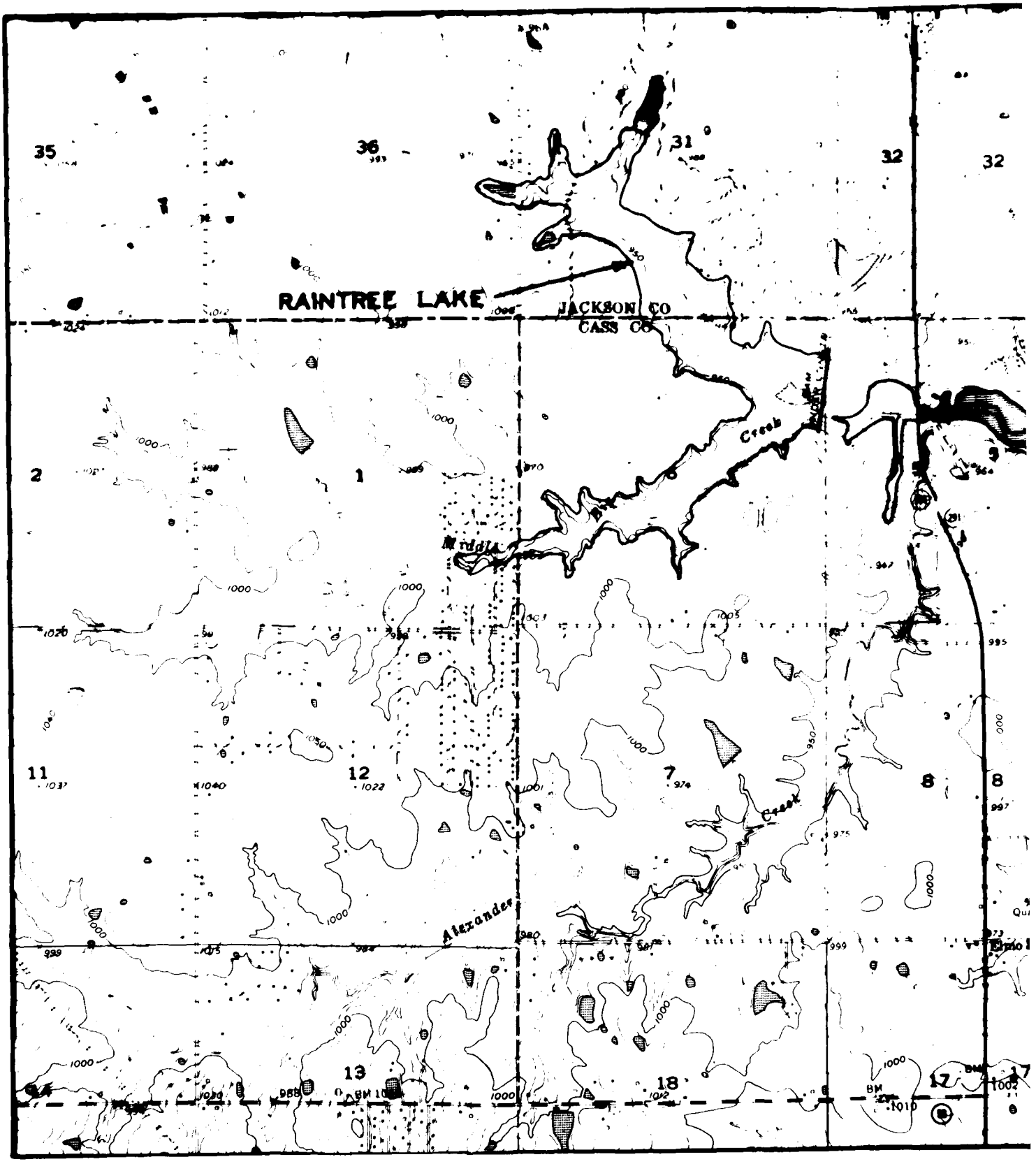

LAKE WINNEBAGO
MISSOURI
VICINITY MAP
SCALE IN MILES
100 0 100 200
KANSAS CITY
KANSAS
MISSOURI
JOHNSON COUNTY
JACKSON COUNTY
LEES SUMMIT
GRANDVIEW
RAINTREE LAKE
CASS COUNTY
JACKSON COUNTY
BELTON
PLEASANT HILL
LAKE WINNEBAGO
JOHNSON COUNTY
MIAMI COUNTY
LAKE WINNEBAGO
LOCATION MAP
SCALE IN MILES
0 1 2 3 4 5
N

PLATE 1


RAINTREE LAKE
JACKSON CO
CASS CO
Creek
Creek
Alexander
35
36
31
32
32
2
1
11
12
7
8
8
13
18
17
17
BM
1010

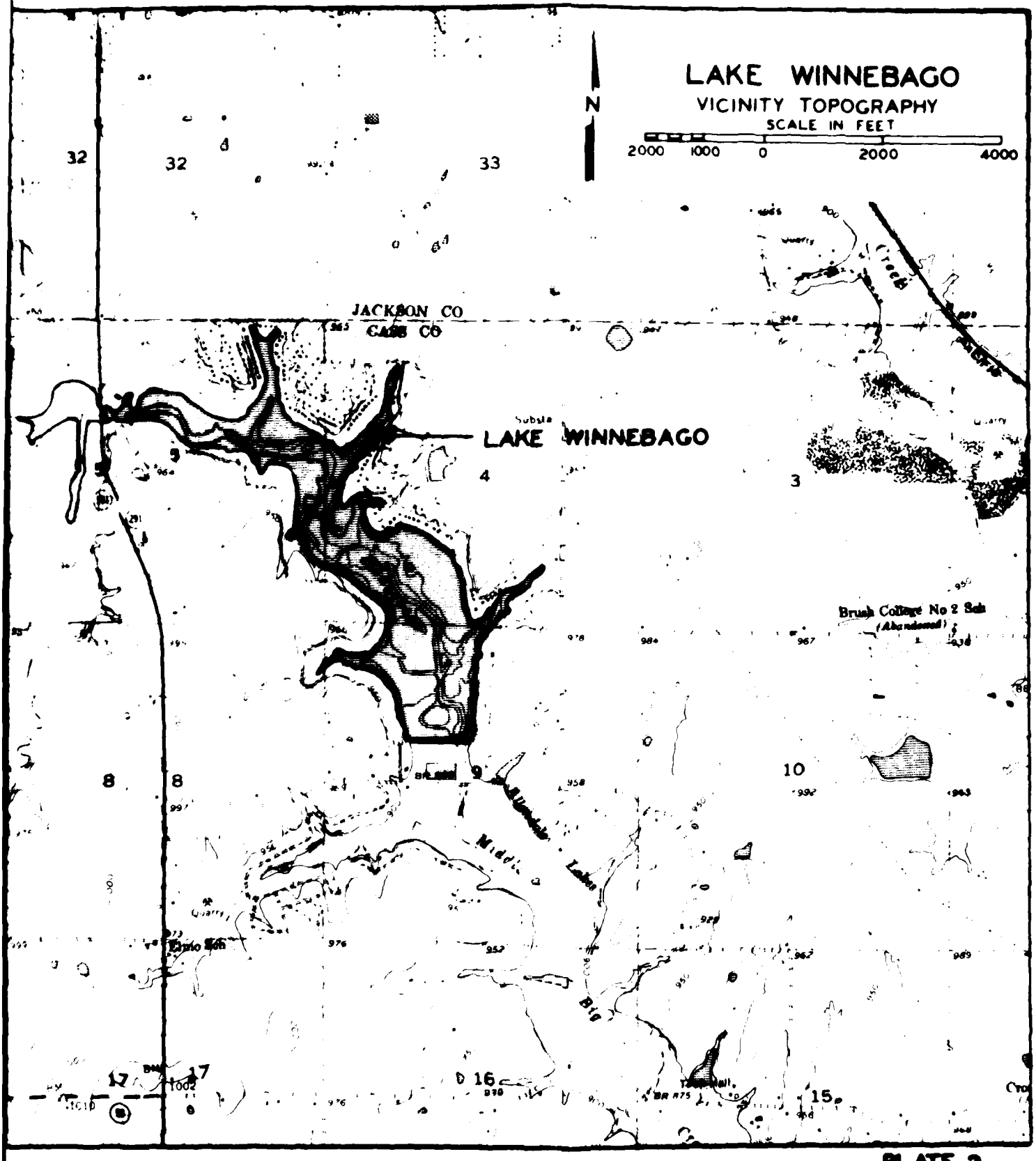

LAKE WINNEBAGO
VICINITY TOPOGRAPHY
SCALE IN FEET
2000 1000 0 2000 4000
N
JACKSON CO
CASS CO
LAKE WINNEBAGO
Brush College No 2 Sch
(Abandoned)
Middle Lake
Big
32
33
4
3
8
9
10
17
16
15

PLATE 2

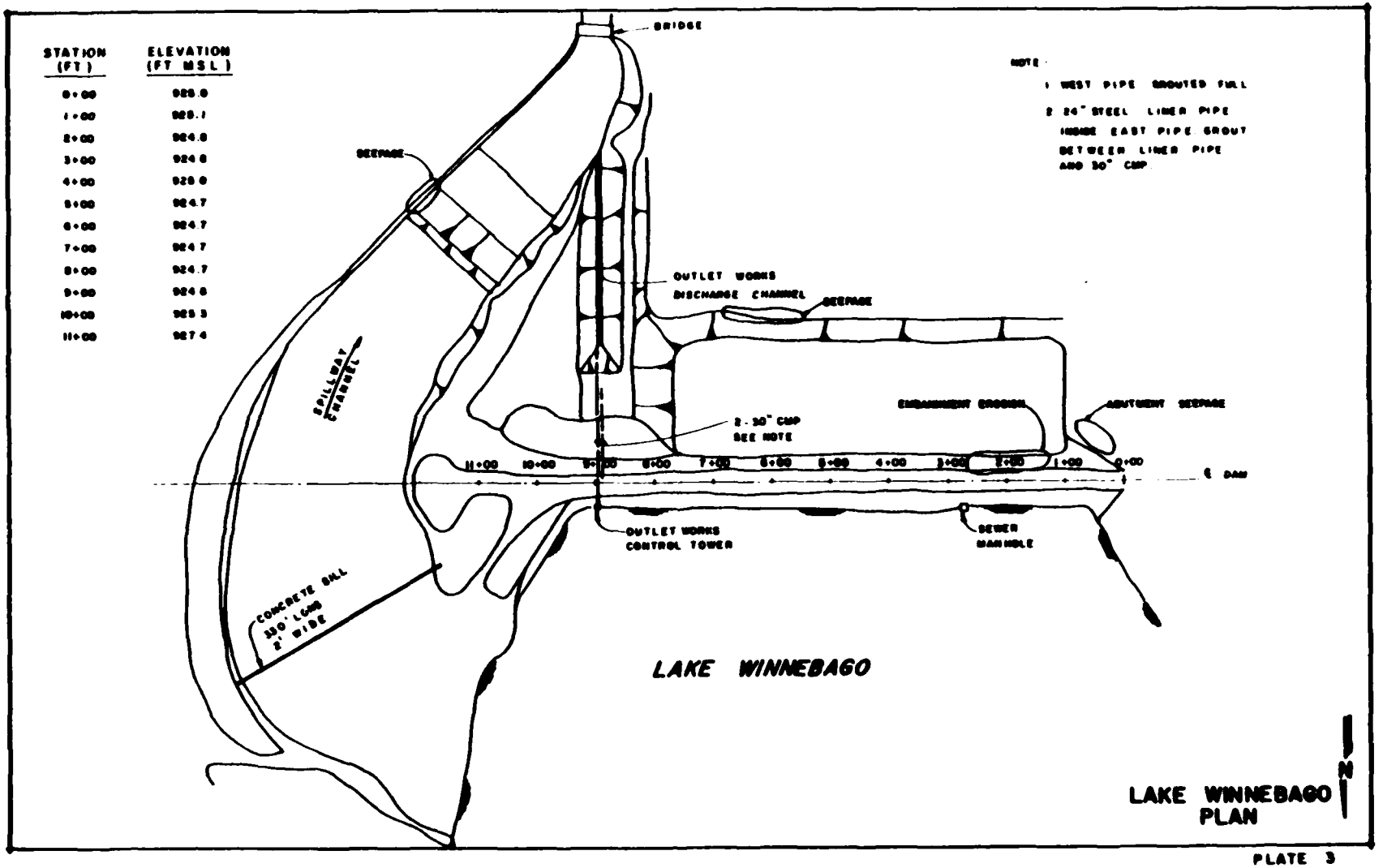
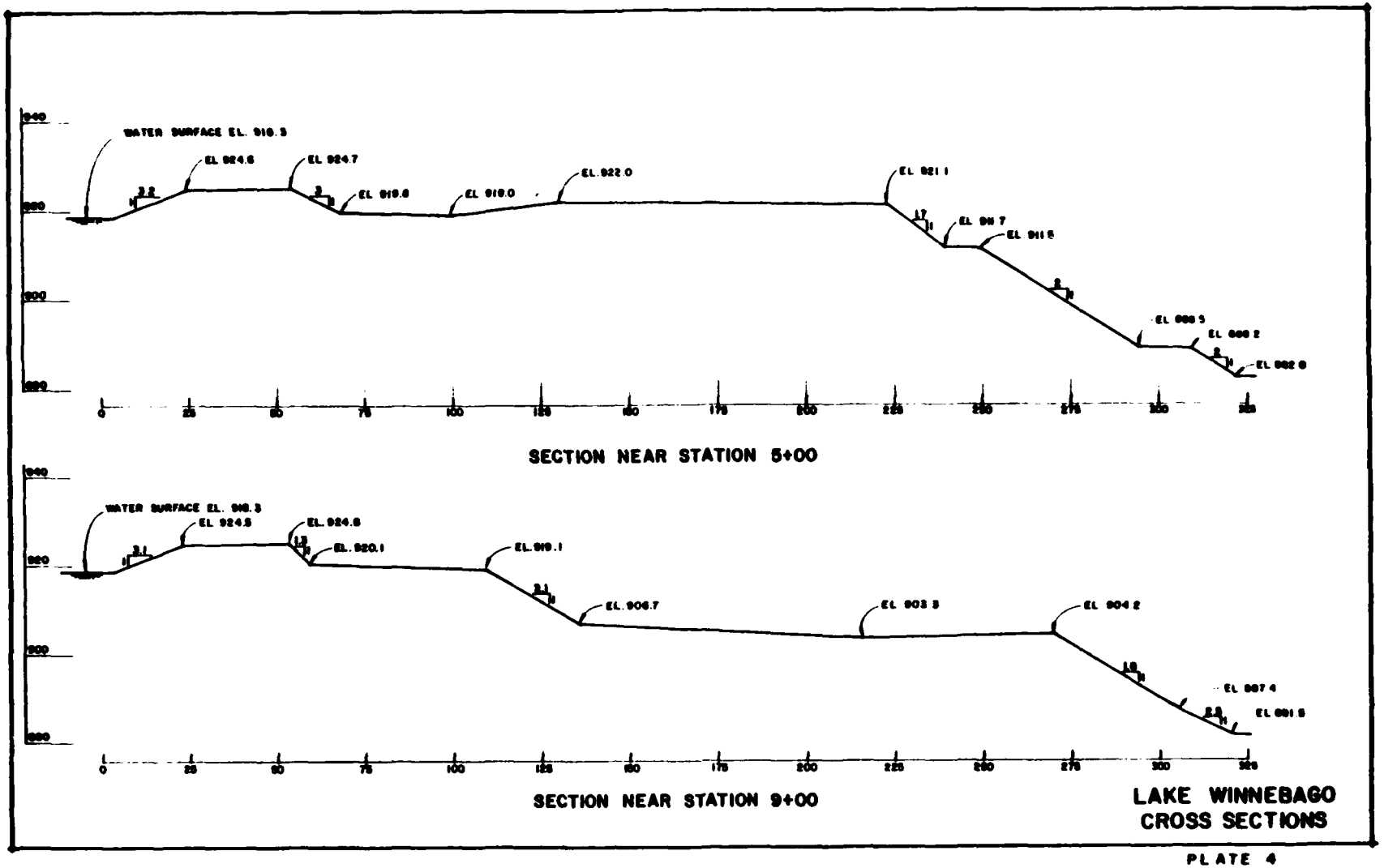

STATION (FT)
ELEVATION (FT MSL)
0+00 928.0
1+00 928.1
2+00 924.8
3+00 924.8
4+00 928.0
5+00 924.7
6+00 924.7
7+00 924.7
8+00 924.7
9+00 924.8
10+00 925.3
11+00 927.4
BRIDGE
SEEPAGE
NOTE:
1 WEST PIPE GROUTED FULL
2 24" STEEL LINER PIPE INSIDE EAST PIPE GROUT BETWEEN LINER PIPE AND 30" CMP
OUTLET WORKS DISCHARGE CHANNEL
SEEPAGE
SPILLWAY CHANNEL
EMBANKMENT DRAINS
ABUTMENT SEEPAGE
2 - 30" CMP SEE NOTE
11+00 10+00 9+00 8+00 7+00 6+00 5+00 4+00 3+00 2+00 1+00 0+00
℄ DAM
OUTLET WORKS CONTROL TOWER
SEWER MANHOLE
CONCRETE SILL 330' LONG 2' WIDE
LAKE WINNEBAGO
N
LAKE WINNEBAGO PLAN

PLATE 3

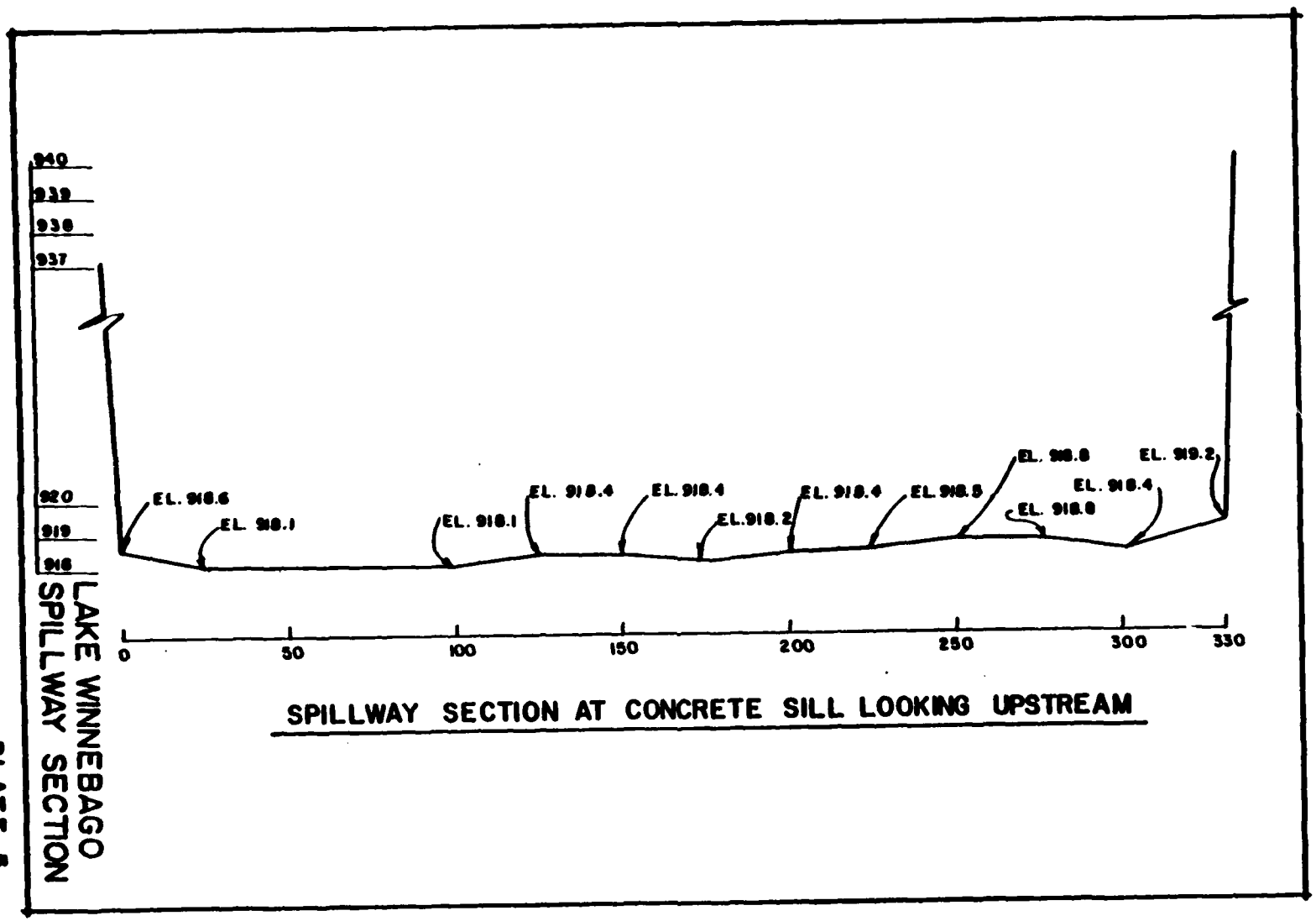


SECTION NEAR STATION 5+00

SECTION NEAR STATION 9+00

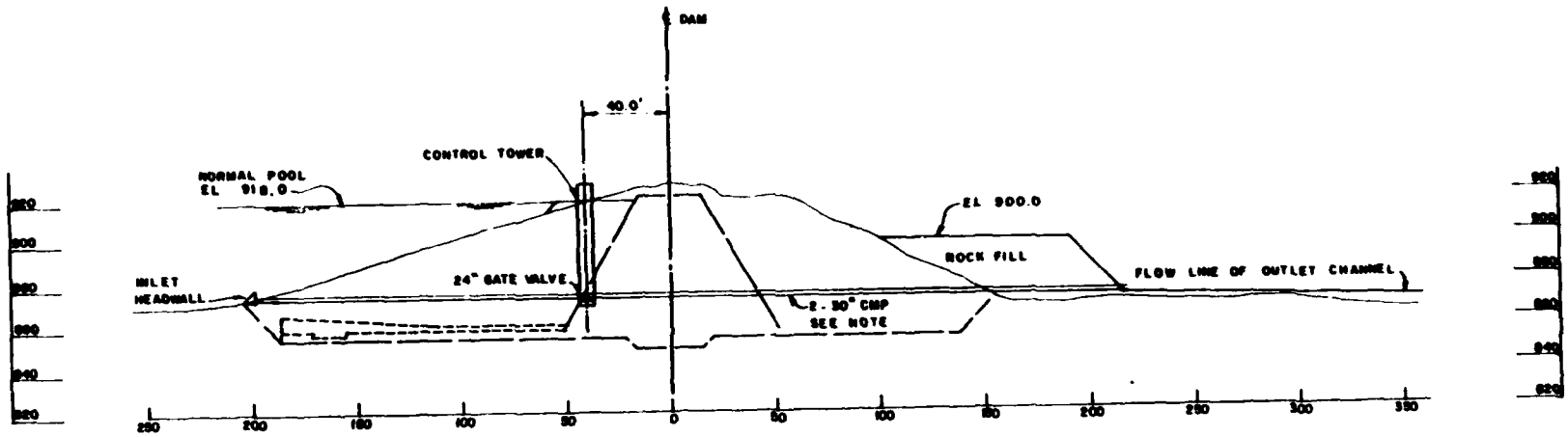
LAKE WINNEBAGO
CROSS SECTIONS

PLATE 4



SPILLWAY SECTION AT CONCRETE SILL LOOKING UPSTREAM

PLATE 5



NOTES

1. WEST PIPE GROUTED FULL
2. 24" STEEL LINER PIPE PLACED INSIDE EAST PIPE. GROUT BETWEEN LINER AND 30" CMP.

LAKE WINNEBAGO
OUTLET WORKS SECTION

PLATE 6

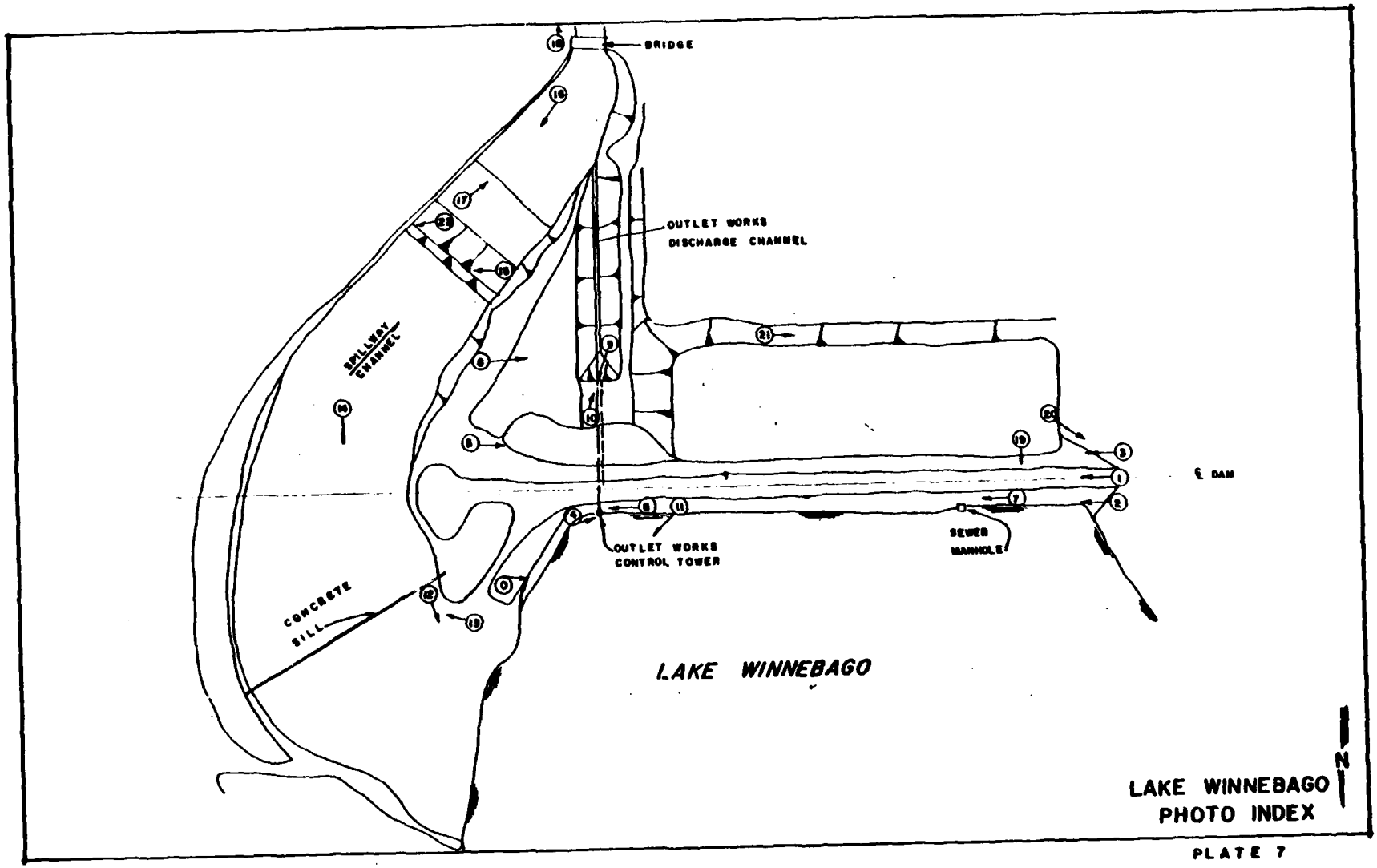

BRIDGE
OUTLET WORKS
DISCHARGE CHANNEL
SPILLWAY
CHANNEL
OUTLET WORKS
CONTROL TOWER
SEWER
MANHOLE
℄ DAM
CONCRETE
SILL
LAKE WINNEBAGO
N
LAKE WINNEBAGO
PHOTO INDEX

PLATE 7

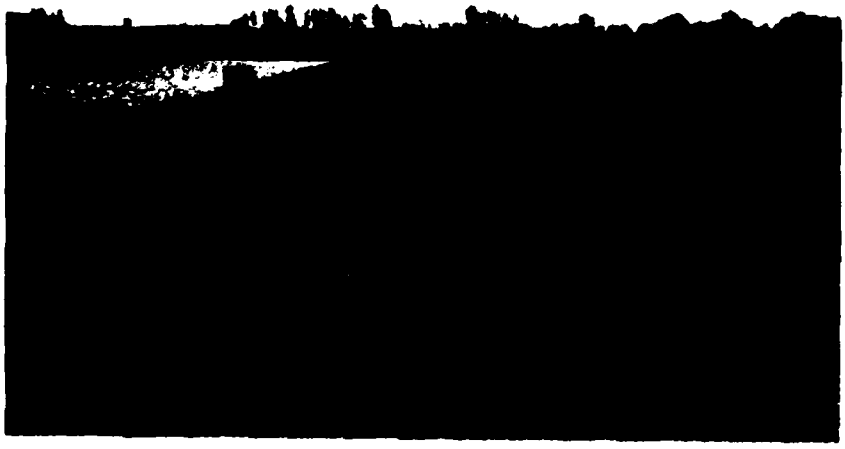


PHOTO 1: CREST OF DAM

PHOTO 2: UPSTREAM FACE OF DAM

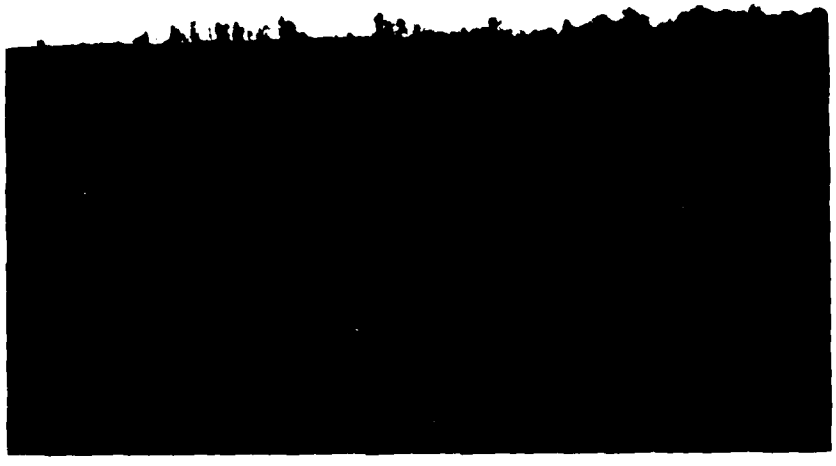


PHOTO 3: DOWNSTREAM FACE OF DAM

PHOTO 4: UPSTREAM FACE OF DAM VIEWED FROM LEFT ABUTMENT

PHOTO 5: DOWNSTREAM FACE OF DAM VIEWED FROM LEFT ABUTMENT

PHOTO 6: OVERVIEW OF BACK SIDE OF DAM

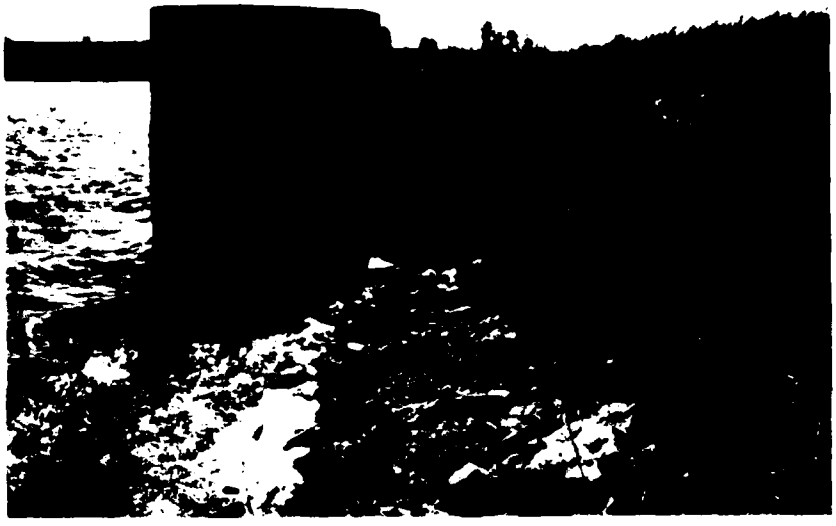


PHOTO 7: SEWER LINE STRUCTURE

PHOTO 8: OUTLET STRUCTURE

PHOTO 9: OUTLET END OF OUTLET PIPE

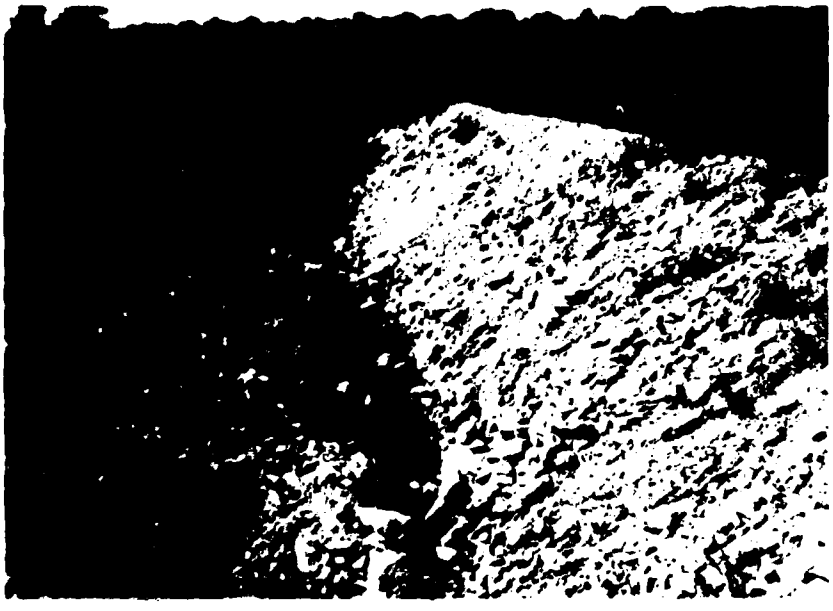


PHOTO 10: CHANNEL BELOW OUTLET PIPE

PHOTO 11: EMERGENCY SPILLWAY

PHOTO 12: EMERGENCY SPILLWAY LOOKING UPSTREAM FROM SILL

PHOTO 13: EMERGENCY SPILLWAY LOOKING DOWNSTREAM

PHOTO 14: EMERGENCY SPILLWAY CHANNEL

PHOTO 15: EMERGENCY SPILLWAY OVERFALL

PHOTO 16: EMERGENCY SPILLWAY OVERFALL VIEWED FROM DOWNSTREAM

PHOTO 17: CHANNEL BELOW EMERGENCY SPILLWAY

PHOTO 18: CHANNEL BELOW ROADWAY DOWNSTREAM OF DAM

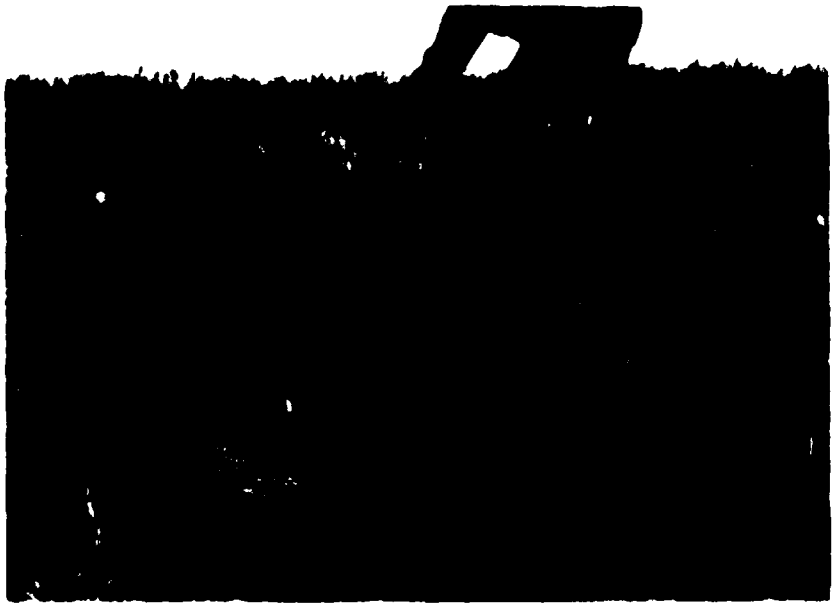


PHOTO 19: EROSION CHANNEL ON BACK SIDE OF DAM

PHOTO 20: SEEPAGE AT RIGHT ABUTMENT CONTACT

PHOTO 21: SEEPAGE BELOW EMBANKMENT

PHOTO 22: SEEPAGE FROM LEFT BANK OF SPILLWAY CHANNEL AT OVERFALL

APPENDIX A

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

1. The Soil Conservation Service (SCS) dimensionless unit hydrograph and HEC-1 (1) were used to develop the inflow hydrographs. Hydrologic inputs are as follows:

a. Forty-eight hour, probable maximum precipitation determined from U.S. Weather Bureau Hydrometeorological Report No. 33.

200 square mile, 24 hour rainfall inches	- 24.8
12.53 square mile, 6 hour percent of 24 hour 200 square mile rainfall	- 99%
12.53 square mile, 12 hour percent of 24 hour 200 square mile rainfall	- 118%
12.53 square mile, 24 hour percent of 24 hour 200 square mile rainfall	- 128%
12.53 square mile, 48 hour percent of 24 hour 200 square mile rainfall	- 138%

b. Drainage area = 19.98 square miles (includes 7.45 square miles above Raintree Lake Dam).

c. Time of concentration: $T_c = (11.9 \times L^3/H)^{0.385}$ = 3.22 hours = 193 minutes (L = length of longest watercourse in miles, H = elevation difference in feet) (2)

d. The soil associations in this watershed are Polo-Sogn, Sharpsburg-Higginsville, Blackoar-Zook, and Dennis-Roseland. The percentages of soils in each of the SCS soil groups are as follows: 60% in group C, 35% in group B, and 5% in group D (3).

e. Losses were determined in accordance with SCS methods for determining runoff using a curve number of 86 for antecedent moisture condition III and a curve number of 72 for antecedent moisture condition II. The major land uses in the watershed were low-density urban, row crops, pasture-range, and woods.

2. Spillway discharges were based on backwater analysis using cross sections from the plans for spillway alteration and computer program HEC-2,(4).

Discharge rates over the top of the dam are based on the weir equation:

$Q = CLH^{1.5}$ (C = 3.0 to 3.06, L = 1,000 to 1,200 feet, H is head over the dam).

3. The elevation-storage relationship above normal pool elevation was constructed by planimetering the area enclosed within each contour above normal pool. The storage between two elevations was computed by multiplying the average of the areas at the two elevations by the elevation difference. The summation of these increments below a given elevation is the storage below that level.

4. Floods are routed through the spillway using HEC-1, modified Puls to determine the capability of the spillway.

(1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, September 1978, Davis, California.

(2) U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1974, Washington, D.C.

(3) Mid-America Regional Council, Regional Soils Guide, March 1976, Kansas City, Missouri.

(4) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Water Surface Profiles (HEC-2), November 1976, Davis, California.

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION     JULY 1978
  LAST MODIFIC.  ON  26 FEB 79
**********
    1  A1    MISSOURI DAM INSPECTIONS
    2  A2    PMF ROUTING FOR LAKE WINNEBAGO
    3  A3    DRAINAGE AREA = 12.53 SQ MI
    4  B   288       0      10       0       0       0       0       0       0       0
    5  B1    5
    6  J     1       9       1
    7  J1   .2      .25     .3      .35     .4      .5      .75     .8      1.
    8  K     0       1                               3       1
    9  K1 RAINTREE LAKE DAM      (48HR. PROBABLE MAXIMUM RUNOFF)
   10  M     1       2   7.452                       1
   11  P           25.0     101     120     130     140
   12  T                                                      -1     -82
   13  W2          0.72
   14  X                   1
   15  K     1       2                                       1
   16  K1 ROUTINE THROUGH RAINTREE LAKE RESERVOIR
   17  Y                                       1       1
   18  Y1    1                                                -955.0      -1
   19  Y4955.0 956.0   956.6   957.9   958.9   960.2   961.3   962.3   963.2   963.5
   20  Y4963.7 963.9   964.1   964.6   965.0   965.3   965.8   966.6   967.5
   21  Y5 0.   500.    1000.   2500.   4000.   6000.   8000.   10000.  12000.  12500.
   22  Y513000.13500.  14000.  15000.  16019.  17294.  19688.  26760.  37105.
   23  SS 0.   9.5     224.    888.5   2255.5  4877.   9651.5
   24  SE910.  920.    930.    940.    950.    960.    970.
   25  SS955.0
   26  SD 964.9      0.      1.5     0.
   27  K           MAIN                        1       3       1
   28  K1    LAKE WINNEBAGO UNREGULATED INFLOW - 48 HOUR PMF
   29  M     1       212.53                      1
   30  P      24.8    99.     118.    128.    138.
   31  T                                                      -1     -86
   32  W2     1.93
   33  X                   1
   34  K     2    HEAD                       1       3       1
   35  K1      COMBINE WATERSHED RUNOFF AND RAINTREE LAKE OUTFLOWS
   36  K     1     DAM                       1       3       1
   37  K1    ROUTE COMBINED PMF THROUGH LAKE WINNEBAGO DAM
   38  Y                                   1
   39  Y1    1                                               -918.       -1
   40  Y4918.  919.3   920.4   921.4   922.7   923.5   924.7   925.4   927.1   928.7
   41  Y4930.1
   42  Y50.    1000.   3000.   5000.   8000.   10000.  13000.  16650.  30650.  49440.
   43  Y569390.
   44  SS0.    2900.   6930.   12570.
   45  SE910.  920.    930.    940.
   46  SS918.
   47  SD924.7
   48  K     99
```

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT 1
ROUTE HYDROGRAPH TO 2
RUNOFF HYDROGRAPH AT MAIN
COMBINE 2 HYDROGRAPHS AT HEAD
ROUTE HYDROGRAPH TO DAM
END OF NETWORK

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERS         JULY 1978
  LAST MODIFICATION  26 FEB 79
**********

RUN  DATE= 08/13/79.
     TIME= 16.46.22.
```

MISSOURI DAM INSPECTIONS
PMF ROUTING FOR LAKE WINNEBAGO
DRAINAGE AREA = 12.53 SQ MI

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	10	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 9 LRTIO= 1

RTIOS= .20 .25 .30 .35 .40 .50 .75 .80 1.00

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

SUB-AREA RUNOFF COMPUTATION

RAINTREE LAKE DAM (48HR. PROBABLE MAXIMUM RUNOFF)

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	3	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	7.45	0.00	7.45	1.00	0.000	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.00	101.00	120.00	130.00	140.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-82.00	0.00	0.00

CURVE NO = -82.00 WETNESS = -1.00 EFFECT CN = 82.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .72

RECESSION DATA
STRTQ= 0.00 QRCSN= 0.00 RTIOR= 1.00

UNIT HYDROGRAPH 24 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .72 VOL= 1.00

478.	1496.	3119.	4248.	4465.	4027.	3261.	2242.	1567.	1133.
817.	578.	414.	294.	209.	150.	107.	76.	55.	41.
30.	20.	10.	1.						

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .. ..

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	918.00	918.00	924.70
STORAGE	2320.	2320.	4794.
OUTFLOW	0.	0.	13000.

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
.20	923.37	0.00	4258.	9672.	0.00	43.00	0.00
.25	924.44	0.00	4690.	12352.	0.00	43.00	0.00
.30	925.27	.57	5023.	15965.	2.17	42.83	0.00
.35	925.80	1.10	5236.	19917.	3.17	42.50	0.00
.40	926.22	1.52	5407.	23417.	3.83	42.33	0.00
.50	927.02	2.32	5727.	29955.	4.83	42.17	0.00
.75	928.47	3.77	6314.	46745.	7.00	42.00	0.00
.80	928.76	4.06	6428.	50225.	7.17	42.00	0.00
1.00	929.89	5.19	6886.	66409.	8.17	41.67	0.00

END

DATE
FILMED

11-81

DTIC