AD-A106 737 INTERNATIONAL ENGINEERING CO INC SAN FRANCISCO CA F/G 13/13
NATIONAL DAM SAFETY PROGRAM. UPSTREAM DAM (MO 31080), MISSISSIP--ETC(U)
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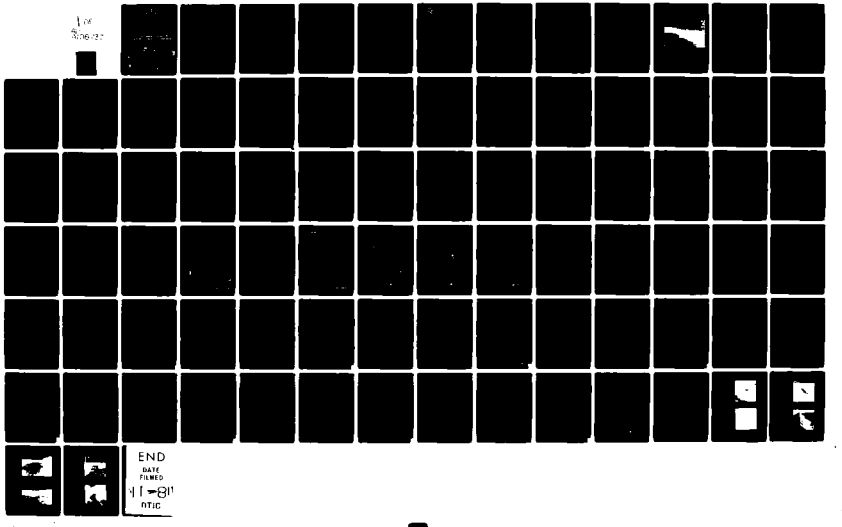

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UPSTREAM DAM
MADISON COUNTY, MISSOURI
MO 31080

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
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St. Louis District

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

FOR: STATE OF MISSOURI

JUNE 1979

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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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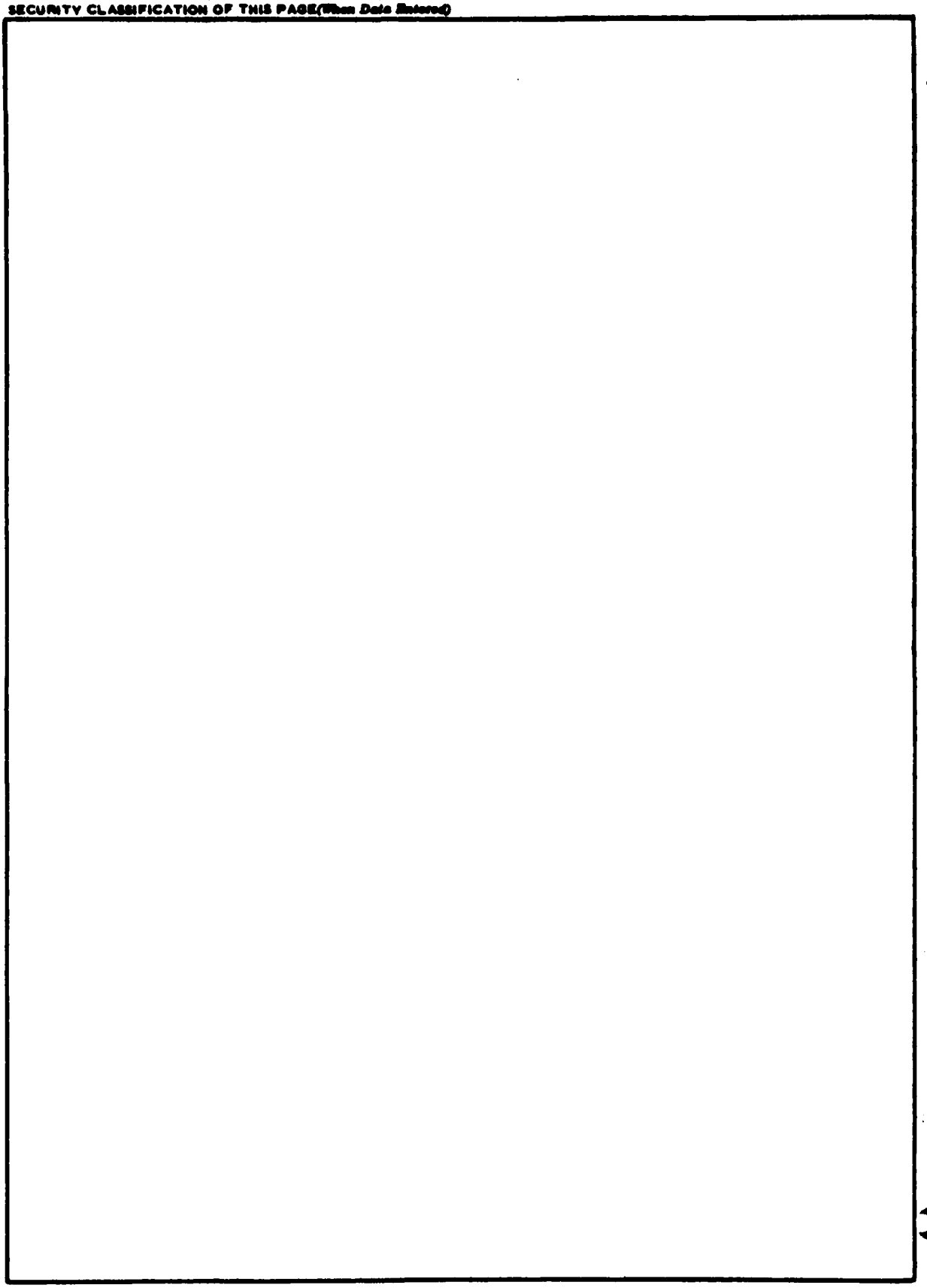

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

Summary of the Field Inspections

Shortly after the initial field inspection (late March 1979) by International Engineering Company, Inc., it was determined by the State of Missouri that an emergency situation had developed at the Upstream Dam (early April 1979), due to severe weather conditions.

The Corps of Engineers (Memphis District) was authorized by the State to take emergency actions to prevent a possible failure of the dam. Prior to and immediately following the remedial emergency actions, the Memphis District performed field surveys (see plate 4 thru 8 in the Appendix of this report).

Subsequent to the remedial measures at the Upstream Dam, the firm of International Engineering Company prepared a dam inspection report based on the field survey data by the Memphis District performed after the repairs were made.

Therefore, the Dam Safety Office has reclassified the Upstream Dam from unsafe, emergency status to unsafe, non-emergency based on the facts presented herein.

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

IN REPLY REFER TO

7 November 1979

SUBJECT: Upstream Dam Phase I Inspection Report

This report presents the result of field inspections and evaluation of the Upstream Dam (MO. 31080).

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 because emerging seepage and soft soil conditions on the excessively steep downstream face raise serious questions as to the stability of this dam.

In addition, it has been determined that the spillway can contain only 12 percent of the Probable Maximum Flood without significant erosion of the spillway and embankment.

SUBMITTED BY: SIGNED
Chief, Engineering Division

07 NOV 1979
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer

07 NOV 1979
Date

UPSTREAM DAM
MADISON COUNTY, MISSOURI

MISSOURI INVENTORY NO. 31080

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY
INTERNATIONAL ENGINEERING COMPANY, INC.
CONSULTING ENGINEERS
SAN FRANCISCO, CALIFORNIA

UNDER DIRECTION OF
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
FOR
GOVERNOR OF MISSOURI

JUNE 1979

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Upstream Dam
State	Missouri
County	Madison
Stream	Toler Creek (Tributary to Saline Creek)
Date of Inspection	29 March 1979

The Upstream Dam was inspected by a civil engineer and an engineering geologist from International Engineering Company, Inc. of San Francisco, California. This dam is owned by Anschutz Uranium Corporation of Denver, Colorado. The purpose of the inspection was to assess the general condition of the dam with respect to safety. The assessment was based on an evaluation of the available data, a visual inspection and an evaluation of the hydrology and hydraulics of the site to determine if the dam poses hazards to human life or property. The purpose of the dam is to provide impoundment for runoff. The water was used in the milling process of lead ore.

The Upstream Dam was inspected using the "Recommended Guidelines for Safety Inspection of Dams" furnished by the Department of the Army, Office of the Chief of Engineers. Based on these Guidelines, this dam is classified as small. The U.S. Corps of Engineers has classified it as having a high downstream hazard potential to indicate that failure of this dam could threaten life and property. The damage zone, estimated by the U.S. Corps of Engineers, extends approximately 8 miles downstream of the dam. The city of Fredericktown and three state highway bridges are within this damage zone.

The results of the inspection and evaluation indicate that the combined capacity of the principal and emergency spillways does not meet the criteria given in the Guidelines for a dam with the size and hazard potential of the Upstream Dam. As a small dam with a high hazard potential, it is required by the Guidelines to pass 50 to 100 percent of the Probable Maximum Flood (PMF) without overtopping the crest. The spillway design flood adopted for this dam is 100 percent of the PMF because the consequences of failure are serious since it is only about 1/2-mile from a residential area of Fredericktown. The PMF is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that is reasonably possible in the region. It was calculated that the principal spillway could pass a 100-year flood (a flood having a one percent chance of being equalled or exceeded in any 1 year) without overtopping the dam. It was also estimated that the principal spillway could pass 12 percent of the PMF without significant erosion of the spillway or embankment. It was estimated that discharge through the emergency spillway would occur for floods greater than 25 percent of the PMF. However, the principal and emergency spillways cannot pass 50 percent of the PMF without significant erosion of the principal spillway and embankment.

The principal and emergency spillways should be enlarged and/or the freeboard increased so that the PMF can be passed without overtopping the dam crest and without significant erosion of the spillways and embankment. Adequate erosion protection should be provided in both spillways so that they can withstand the peak discharge velocity resulting from the PMF. The principal spillway side slopes should be laid back to minimize the potential for sloughing. The downstream channel of the emergency spillway should be directed away from the toe of the dam.

Erosion protection should be provided on the downstream face of the dam. Adequate protection to resist wave action should be provided on the upstream face. Erosion protection of the soils in the borrow areas at both abutments should be furnished.

There appear to be serious deficiencies in the stability of this dam. Seepage and stability analyses of the dam are not available. These studies should be performed by a professional engineer experienced in the design and construction of earthfill dams. The necessary data for these analyses would be obtained from additional investigations. These investigations should consist of field exploration and soil sampling and a laboratory testing program to obtain the engineering parameters necessary for the analyses.

Remedial work should be done under the direction of a professional engineer experienced in earthfill dam design and construction. Specific remedial work should be addressed to controlling the seepage condition at the downstream toe of the dam. The small trees should be removed from the dam so that a potential seepage problem is eliminated.

An inspection and maintenance program should be initiated. Periodic inspections should be made and documented by qualified personnel to observe the performance of the dam and spillways.

It is recommended that the owner take action to correct the deficiencies described.

Kenneth B. King, P.E.

Michael P. Forrest, P.E.

Donald R. Sanders, R.G.

OVERVIEW OF THE UPSTREAM DAM AND RESERVOIR FROM RIGHT ABUTMENT

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
UPSTREAM DAM
ID NO. 31080

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
UPSTREAM DAM - ID NO. 31080

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

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

b. Purpose of Inspection. The purpose of the inspection was to assess the general condition of the dam with respect to safety, based on available data and visual inspection, 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 Upstream Dam is an earthfill dam that is used to impound water.

(2) There are two uncontrolled spillways at the dam. The principal spillway is located at the left abutment and the emergency spillway is at the right abutment. The emergency spillway crest is 4 feet higher than the principal spillway crest.

b. Location. The dam is located in the northeast portion of Madison County, Missouri, as shown in Plate 1. The dam (shown in Plate 2) is located in Section 21, Township 33 North, Range 7 East.

c. Size Classification. This dam is less than 40 feet high and the impoundment storage is less than 1000 acre-feet; therefore, this dam is in the small size classification, according to the "Recommended Guidelines for Safety Inspection of Dams."

d. Hazard Classification. The U.S. Corps of Engineers has classified this dam in the high hazard potential category. The estimated damage zone, as provided by the Corps of Engineers, extends approximately 8 miles downstream of the dam. The city of Fredericktown and three state highway bridges are within this distance.

e. Ownership. This dam is owned by:

Anschutz Uranium Corporation
2400 Anaconda Tower
555 17th Street
Denver, CO 80202

f. Purpose of Dam. The purpose of the dam is to impound runoff. The water was used in the milling process of lead ore.

g. Design and Construction History. There are no design and construction data available. The dam was breached prior to the 1977 failure of the Main Tailings Dam (I.D. No. 31082), which is located immediately downstream from the Upstream Dam. The Upstream Dam was repaired by constructing a plug in the breach in October 1977. National Lead Industries was the owner of the property and dam in 1977. The property was then sold to Mr. Silas Dees of Madison County who in turn sold it to Nedlog Corporation of Colorado. Anschutz Uranium Corporation purchased the property from Nedlog in March 1979. In mid-April 1979, the Memphis District, Corps of Engineers, did emergency work on the dam and spillways.

h. Normal Operating Procedures. The outflow of surface water runoff would pass through the principal spillway on the left abutment. If the reservoir water surface would rise to a level 4 feet above the principal spillway crest, runoff would then also pass through the emergency spillway on the right abutment.

1.3 PERTINENT DATA

Field surveys were made by the Memphis District, Corps of Engineers, on 14 April and 18 April 1979. The survey information is presented in Plates 4 through 8.

a. Drainage Area. 232 Acres (Topographic Quadrangle; 1:24,000 scale, Fredericktown, SE Mo., AFC unedited advanced print, 1977).

b. Discharge at Damsite.

(1) Outlet pipe. There is no outlet pipe at this dam. Not applicable.

(2) Combined discharge for principal and emergency spillways for pool at top of dam (El. 863.8) - 820 cfs.

(3) Maximum experienced outflow at damsite - no available information.

c. Elevation (Feet Above M.S.L.)[1/]

(1) Top of dam - Varies from El. 863.8 to El. 866.9.

(2) Streambed at downstream toe of dam - El. 830 ±.

(3) Spillway crest -

(a) Principal Spillway - El. 856.0.
(b) Emergency Spillway - El. 860.0.

(4) Reservoir level on date of survey (14 April 1979) - El. 862.2.

d. Reservoir.

(1) Length of pool at elevation of principal spillway crest (El. 856.0) - 1800 feet ±.

(2) Length of pool at elevation of top of dam (El. 863.8) - 2500 feet ±. (from Topographic Quadrangle; 1:24,000 scale, Fredericktown, SE Mo., AFC unedited advanced print, 1977).

e. Storage.

(1) Top of dam (El. 863.8) - 377 acre-feet.

(2) Emergency spillway crest (El. 860.0) - 279 acre-feet.

(3) Principal spillway crest (El. 856.0) - 195 acre-feet.

f. Reservoir Surface Area.

(1) Top of dam (El. 863.8) - 28.4 acres.

(2) Emergency spillway crest (El. 860.0) - 23.0 acres.

(3) Principal spillway crest (El. 856.0) - 19.0 acres.

1/ Elevations are based on a reference datum of 790.64 feet M.S.L. at the Bench Mark RM-13 as described in Plate 3.

g. Dam.

(1) Type - Earthfill.

(2) Length - 810 feet ±.

(3) Height (maximum above streambed) - 35 feet ±.

(4) Top width - varies from 10 to 15 feet.

(5) Side Slopes -

(a) Downstream slope - varies between 1.6(H) to 1.0(V) and 1.8 to 1.0 at the left and right sections and 2.3 to 1.0 at the plug in the central section of the dam.

(b) Upstream slope - 2.0(H) to 1.0(V). There is local over-steepening above the water level due to wave erosion.

(6) Zoning - The embankment is constructed of brown, sandy clay with gravel. No information pertaining to zoning is available.

(7) Cutoff - There is no information available that pertains to the design or construction of a cutoff.

h. Spillways.

(1) Type - The principal and emergency spillways are uncontrolled open channels.

(2) Control sections -

(a) Principal spillway - 10-foot bottom width, 8-foot depth, and 17-foot top width.

(b) Emergency spillway - Broad V-shape, 5.5-foot depth, and 20.4-foot top width.

(3) Crest Elevations -

(a) Principal spillway - El. 856.0 M.S.L.

(b) Emergency spillway - El. 860.0 M.S.L.

(4) Upstream Channels -

(a) Principal spillway - none.

(b) Emergency spillway - clear wide swale.

(5) Downstream Channels -

(a) Principal spillway - 2700-foot long channel that connects three small ponds. The channel conducts water downstream of the Main Tailings Dam (I.D.

No. 31082). Parts of the channel were cluttered with trees on the date of the inspection (29 March 1979). These trees have since been cleared by the Memphis District, Corps of Engineers, as described in Section 2.2.

(b) Emergency spillway - narrow channel that leads to the tailings pond formed by the Main Tailings Dam.

i. Regulating Outlets. None.

j. Diversion Ditches. None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No design drawings or data were available.

2.2 CONSTRUCTION

No construction data for the dam were available. Stohr[2/] notes that the Upstream Dam had been breached prior to the 28 March 1977 failure of the Main Tailings Dam (I.D. No. 31082). The breach was filled by end-dumping gravelly, silty clay off the edges of the crest of the dam[3/]. The contact between the new fill and the old dam was reported to be steep[3/]. The repair was completed in October 1977. Williams stated that differential settlement and failure of the fill placed in the breach of this dam is a potential hazard[3/]. There is no information pertaining to compaction of the fill in the breach. The reports by Stohr and Williams are in Appendix B.

In mid-April 1979, the Memphis District, Corps of Engineers, did emergency work on the dam and spillways. The emergency work was initiated because runoff from heavy rains reduced the safety of the dam. The freeboard measured on 14 April 1979 when the work began was only 1.6 feet (see Plate 4). The emergency work consisted of clearing the vegetation from the principal spillway, lowering the levels of the principal and emergency spillways and sand-bagging the upstream face of the dam to reduce wave erosion.

2.3 OPERATION

No records of operation are known to exist. The outflow of surface runoff would pass through the principal spillway. If the water surface would rise to a level 4 feet above the crest of the principal spillway, water would also pass through the emergency spillway.

2/ Stohr, C. J., "Engineering Geologic Report on the Silas Dees (Formerly National Lead Tailings) Ponds, Madison County, Missouri", Applied Engineering and Urban Geology, Geology and Land Survey, 15 November 1977.

3/ Williams, J.H., "Addendum to Fredericktown, nee (sic) National Lead, nee (sic) Dees Tailings Dam, Madison County, Missouri", Applied Engineering and Urban Geology, Geology and Land Survey, 14 February 1978.

2.4 EVALUATION

a. Availability. No design or construction records were available. Records concerning the repair of the dam in 1977 were available and are in Appendix B. Survey information provided by the Memphis District, Corps of Engineers, is available and is presented in Plates 4 through 8.

b. Adequacy. The field surveys and visual inspections presented herein are considered adequate to support the conclusions of this report. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available; the lack of this information 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. Not applicable because no design data were available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. The dam was inspected by a civil engineer and an engineering geologist from International Engineering Company, Inc. on 29 March 1979. After the field inspection took place, an emergency situation was declared in April 1979. A field survey was made by the Memphis District, Corps of Engineers, on 14 April 1979 that was done prior to the emergency repair work. The field survey dated 18 April 1979, done after the emergency repair was completed, was used in the hydrologic and hydraulic analyses performed in June 1979. The survey data are presented in Plates 4 through 8.

Mr. L. M. Yarberry, a representative of Anschutz Uranium Corporation met with the inspection team on 28 March 1979. The reservoir created by the Upstream Dam impounds runoff, and the water was used in the milling process of lead ore. Photographs taken during the inspection are included in this report. The field locations of the photographs are shown in Plate 9. The photographs pre-date the emergency work done to the dam and spillways by the Corps of Engineers.

b. Project Geology. Bedrock in the area consists of dolomite of Upper Cambrian Age (Geologic Map of Missouri, Missouri Geological Survey, scale 1:500,000, 1979). Small areas of Precambrian igneous rocks (granitics) underlie some of the peaks in the area. Soil cover consists of reddish brown sandy clay of unknown thickness. Both abutments of the dam were used as borrow sources for the dam. The soil at the abutments consists of orange-brown sandy clayey soil with rock fragments. Underlying this soil, exposures of very stiff red-brown and gray plastic clay were observed.

c. Dam. The plan of the dam is shown in Plate 3. The profiles and cross-sections of the dam and spillway are shown in Plates 4 through 8.

There is no vegetation on the 175-foot long plug in the central section of the dam. Small trees and grass are growing on the downstream slope to the left and right of the repaired portion. Small trees and grass are growing on the upstream slope, although the grass cover is thinner than on the downstream slope.

Small scarps (about 1 to 2 feet high) were visible at the downstream toe to the right of the plug, but these are not due to recent slides because they are heavily overgrown. There are erosion rills on the downstream face, particularly on the plug where no vegetation is present. Wave action is eroding the upstream face of the dam. A beach and an 18-inch scarp have been formed by wave action. The upstream slope is steep and, locally, it is steeper than 1(H) to 1(V).

Seepage was observed emerging from the downstream toe of the dam at the location of the plug (repaired portion) during a brief visit to the dam on 28 March 1979; no rain fell that day. The seeps were flowing at an estimated 1 to 2 gpm and the water was clear. Downstream of the toe at the plug, the ground was soft to a depth of 12 to 18 inches. Heavy rains on 29 March 1979 obscured the seepage.

A darkened zone on the downstream face of the repaired section of the dam was apparent on 28 March 1979 (see Photos 5 and 6). This zone may be due to higher moisture from seepage through the dam. The zone was less noticeable on 29 March when it was raining heavily.

The difference in elevation between the water surface and the low point in the dam crest was 1.6 feet on the date that the survey was made (14 April 1979). The elevation difference from the principal spillway crest to the low point in the dam crest is 7.8 feet. The elevation difference from the emergency spillway crest to the low point in the dam crest is 3.8 feet.

Except for the minor protection afforded by vegetation, no erosion protection exists on the upstream and downstream faces of the embankment.

d. Appurtenant Structures. The emergency spillway is located at the right abutment. This spillway was excavated in firm clayey soil. The downstream channel is poorly defined and shallow, and it curves toward the toe of the dam. Erosion of the downstream channel was observed. The spillway discharges into the tailings pond formed by the Main Tailings Dam (I.D. No. 31082).

The principal spillway, located at the left abutment, is at a level 4 feet below the emergency spillway. The principal spillway consists of a 2700-foot long, U-shaped channel in sandy gravelly clayey soil. The channel connects three small ponds that are located in small drainages. This spillway discharges immediately downstream of the Main Tailings Dam. Fallen trees were observed in the channel during the inspection on 29 March 1979. These trees have since been cleared by the Corps of Engineers. The spillway side slopes are steep.

e. Reservoir Area. No evidence of landslides along the shoreline was observed. Erosion of the shoreline was minimal. Most of the watershed is covered with natural woodland vegetation. Erosion is occurring in the borrow areas at the abutments. No structures that could be affected by backwater flooding were observed to exist in the watershed.

f. Downstream Channels. The Upstream Dam was constructed on Toler Creek. Lead tailings impounded by the Main Tailings Dam (I.D. No. 31082) are immediately downstream of the Upstream Dam (see Plate 2). Downstream of the Main Tailings Dam, the drainage is braided across a plain with sand tailings sediment from the 1977 failure of the tailings dam. Toler Creek flows through residential areas in Cobalt Village and Fredericktown for 1.8 miles before it enters Saline Creek. Saline Creek flows into the Little St. Francis River about 0.5-mile northwest of Fredericktown.

3.2 EVALUATION

There appear to be serious deficiencies in the stability condition of this dam. Wave erosion is causing severe erosion of the upstream face of the dam. Also, very steep slopes were observed to occur locally on the upstream face above the reservoir level. The downstream slope on either side of the 175-foot plugged section appears to be too steep for a clay embankment. Erosion is occurring on the downstream slope of the dam at the plugged section.

The emerging seepage and soft soil condition at the downstream toe could also adversely affect the stability of the dam. An internal drainage system for the purpose of lowering the phreatic level was apparently not constructed. As a result, the phreatic level is probably high in the embankment, and this reduces its stability. The dark zone observed on the downstream face of the plugged section may be due to higher moisture from seepage through the dam. A high phreatic line in the plugged section would be serious because the plug was reportedly constructed by end-dumping fill into the breach from the dam crest (see Section 2.2); adequate compaction may not have been done. The small trees growing on the face of the dam could also cause a potential seepage hazard along the roots.

The clayey soils in both spillways are subject to erosion. Since both spillways abut on the dam, flood flows could also erode the embankment materials. The emergency spillway curves toward the toe of the dam. Flood discharge would be routed toward the embankment and could cause erosion of the dam. The side slopes of the principal spillway are steep and are subject to sloughing. Erosion of the exposed borrow area soils at the left abutment could cause deposition of material in the principal spillway channel. At the time of the inspection, fallen trees were observed in the spillway channel. These have been removed in mid-April 1979 by the Memphis District, Corps of Engineers.

Only 1.6 feet of freeboard existed on the date of the survey (14 April 1979). This limited freeboard threatened the safety of the dam. The spillways were lowered by the Corps of Engineers to relieve this emergency condition.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

No regulating procedures are known to exist for this dam. The two spillways are uncontrolled. Surface runoff would pass through the principal spillway on the left abutment. If the water surface rises 4 feet above the principal spillway crest, outflow through the emergency spillway will occur.

4.2 MAINTENANCE OF DAM

Information available to the inspection team indicates that the dam is not regularly maintained.

4.3 MAINTENANCE OF OPERATION FACILITIES

There are no operating facilities at this dam. Not applicable.

4.4 DESCRIPTION OF WARNING SYSTEM IN EFFECT

Information available to the inspection team indicates that there is no warning system for this dam.

4.5 EVALUATION

The behavior of the dam should be monitored periodically to observe any indications of instability, such as cracks in the dam, sloughing, sudden settlement, erosion of the dam or spillways, or an increase in the volume or turbidity of emerging seepage. A maintenance program should be initiated for the dam and both spillways.

SECTION 5 - HYDRAULIC AND HYDROLOGIC ANALYSES

5.1 EVALUATION OF FEATURES

a. Design Data. The significant dimensions of the dam and spillways are presented in Section 1 - Project Information, and in the field survey drawings, Plates 4 through 8. The survey dated 18 April 1979 was used in the hydraulic and hydrologic analyses. Hydrologic and hydraulic design information are not available.

For this evaluation, the watershed drainage area, stream lengths, and reservoir areas were obtained from a 1977 AFC unedited advance print of Fredericktown, SE, Mo., 1:24,000 scale Quadrangle. The soil group for this watershed is classified as Goss Cherty Silt Loam, equivalent to a hydrologic soil group B classification, which has a moderate rate of water transmission.

The drainage area of the Upstream Dam, I.D. No. 31080, as shown on Plate 2, is about 232 acres (0.363 square miles). The Main Tailings Dam, I.D. No. 31082, is located approximately 2000 feet downstream. Land use and vegetation patterns of the watershed were determined from field observations and aerial photographs of the area. The drainage area of the Upstream Dam was divided into the following types of land use and vegetal cover:

Type of Cover	Approximate Percent of Area
Woodlands	78
Scattered Woodlands	12
Reservoir	10

The estimated runoff curve numbers (CN) weighted according to the above land cover distribution are CN 50 for the antecedent moisture condition (AMC) II condition, and CN 70 for the AMC III condition. The 10 percent reservoir water surface was entered into the computer program as percent impervious area, and was not included in the weighting of the CN values. Other computed parameters such as basin lag time, unit hydrograph, probable maximum precipitation, losses and net runoff are presented in Appendix A.

Two spillways are located at the dam: a principal spillway and an emergency spillway. They are individually discussed below.

1. Principal Spillway - The principal spillway is located at the west end of the dam. The spillway channel is about 2700 feet long and terminates downstream of the Main Tailings Dam. The channel also diverts runoff from entering the impoundment behind the Main Tailings Dam. It prevents runoff from 34 acres of land located at higher elevations from flowing into the incremental drainage area between the Upstream Dam and the Main

Tailings Dam. The channel profile is shown on Plate 5 and cross-sections are presented in Plates 7A through E and Plate 8. Detailed hydraulic analysis of the flow conditions along the entire length of the channel is beyond the scope of this study.

The spillway entrance is located at Sta. 27+00, and the spillway crest elevation is about El. 856.0. The cross-section at Sta. 26+00 was selected as the control section, assuming the invert is at El. 856.0, which is the elevation of the spillway crest. Two methods were used to derive the spillway discharge rating curve:

- Critical flows at different critical flow depths were computed using the critical flow formula.
- Manning's equation for uniform flow, using the bottom slope of the beginning reach of the channel (Sta. 26+00 to Sta. 25+00) as the average bottom slope (S = 0.0097) and a Manning's "n" of 0.03.

The discharge capacities computed by both methods are almost identical. The maximum capacity of the channel is about 1000 cfs.

2. Emergency Spillway - The emergency spillway is located at the east end of the embankment. The spillway cross-section is presented in Plate 8. The spillway crest is at El. 860.0, which is 4 feet higher than the principal spillway crest elevation. Two methods were used to derive the emergency spillway rating curve:

   - Critical flows at different critical flow depths using the critical flow formula for a trapezoidal section.
   - Weir flow formula using a discharge coefficient of 2.7.

   The results computed by the weir formula were considered more representative of the flow conditions at the entrance section (crest) of the emergency spillway.

Computations of flow over the dam crest were made with the weir flow formula assuming a weir discharge coefficient of 3.0.

The discharge rating curves for flows in the principal and emergency spillways and over the dam crest were combined as one composite discharge rating curve. Data for this combined rating curve are in Appendix A, under the input data listing, as Y4 and Y5 cards, and are also in the computer printouts.

b. Experience Data. Rainfall, streamflow and flood data for the watershed are not available. The principal spillway channel and emergency spillway were deepened in April 1979 by the Memphis District, Corps of Engineers (see Section 2.2). Spillway profiles and cross-sections were prepared by the Memphis District Corps of Engineers (see Plates 4 through 8). There is no available evidence of overtopping of the Upstream Dam.

c. Visual Observations. Specific information on the visual observations is presented in Section 3 - Visual Inspection.

d. Overtopping Potential. The 100-year flood, probable maximum flood (PMF) and floods expressed as percentages of the PMF were computed and routed through the reservoir and both spillways. The PMF is defined as the hypothetical flood event that would result from the most severe combination of critical meteorologic and hydrologic conditions that is reasonably possible at a particular location or region. The Modified Puls Method of spillway routing was employed. For all cases of the spillway flood routing, the level of the reservoir surface was set at El. 856.0 (the crest elevation of the prinicpal spillway) at the start of the flood routing. It was assumed that erosion of the principal and emergency spillway entrance sections will not occur as flood discharges increase. Therefore, the discharge rating curve was computed for the specific cross-sections and configurations as discussed in the previous paragraphs.

Results of the routing studies and overtopping analyses are briefly discussed below:

1. The principal spillway is able to pass the 100-year flood. The maximum reservoir water surface elevation for the 100-year flood is El. 857.4, which is 2.6 feet below the crest elevation of the emergency spillway (El. 860.0).

2. It was estimated that the principal spillway can pass about 25 percent of the PMF (peak outflow was computed as 205 cfs, velocity of 7.2 feet per second and flow depth of about 3.2 feet) before the reservoir water surface reaches the crest elevation of the emergency spillway.

3. It was calculated that the dam would be overtopped during the PMF. However, it was computed that both the principal and emergency spillways combined can pass about 67 percent of the PMF without overtopping the lowest point of the embankment. At 67 percent of the PMF, the discharges from the principal and the emergency spillways are 680 cfs and 140 cfs respectively, with a combined discharge of 820 cfs. The flow depth in the principal spillway is 6.2 feet, with a flow velocity of 10.4 feet per second. The flow depth in the emergency spillway is 3.4 feet, with a flow velocity of about 5.0 feet per second.

A major consideration in evaluating the safety of the dam is assessing the potential for overtopping and subsequent failure of the embankment as a result of erosion. Since the spillway is composed of erodible materials, high velocity discharges in the spillways adjacent to the embankment will lead to significant erosion of the spillway and embankment even if the dam is not overtopped. Based on the Corps of Engineers Manual EM 1110-2-1601, "Hydraulic Design of Flood Control Channels", the maximum permissible velocity for materials found in the two spillways was estimated at about 5 feet per second. Using this as a criterion, it was calculated that approximately 12 percent of the PMF can be passed through the principal spillway without significant erosion. At 12 percent of the PMF, the maximum reservoir water surface elevation would not reach the emergency spillway crest elevation and the outflow would be discharged entirely through the principal spillway. Peak outflow for 12 percent of the PMF is about 60 cfs, at a flow depth of about 2.0 feet at the entrance section, and a velocity of 5 feet per second. Thus, for determining the erosion potential of the embankment section at the spillway entrance, prolonged discharges above 60 cfs in the principal spillway and flow depths greater than 2.0 feet could produce the effects of significant erosion and subsequent embankment failure at this location.

Results of the overtopping analyses are reported in Appendix A and are summarized in the following table.

Flood	Peak Inflow (cfs)	Total Peak Outflow (cfs)	Max. Res. WS Elev. (ft)	Principal Spillway				Emergency Spillway			
				Peak Outflow (cfs)	Spillway Flow Depth (ft)	Spillway Flow Velocity (ft/sec)	Duration Spillway Velocity Over 5 ft/sec (hr)	Peak Outflow (cfs)	Spillway Flow Depth (ft)	Spillway Flow Velocity (ft/sec)	Duration Spillway Velocity Over 5 ft/sec (hr)
25% PMF	594	205	860.0	205	3.2*	7.2*	8.8	-	0.1	0.5	-
50% PMF	1188	546	862.5	483	5.1*	9.5*	13.9	63	2.2	4.0	-
75% PMF	1782	971	864.2**	749	6.5**	10.6**	16.1	171	3.8**	5.2**	1.3
PMF	2376	1781	865.1**	912	7.2**	11.1**	17.8	260	4.5**	5.8**	2.4

* These flow depths and velocities are considered to produce the effects of significant erosion.

** Dam overtopped (Minimum Dam Crest El. 863.8).

Note: Reservoir water surface elevations include the velocity heads corresponding to the velocities computed at the various flow depths for the spillway sections.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Conditions that adversely affect the structural stability of the dam are discussed in Section 3.

b. Design and Construction Data. No design or construction data pertaining to the structural stability of the dam were available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, and lack of this information 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. Operating Records. No appurtenant structures requiring operation exist at this dam and no records were located.

d. Post Construction Changes. The dam was repaired by plugging a breach in October 1977. In mid-April 1979, the Memphis District, Corps of Engineers, did emergency work on the dam and spillways. The upstream face of the dam was sand-bagged and trees were cleared from the principal spillway channel. Both the principal and emergency spillways were lowered to increase the freeboard.

e. Seismic Stability. The dam is located in Seismic Zone 2, as defined in the Uniform Building Code. The clay embankment is saturated for much of its cross-section and the downstream slope is steep, therefore, there appears to be a potential for embankment deformation due to earthquake shaking. The dam would have to be subjected to sufficiently intense shaking for the deformations to occur.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. There are several deficiencies that should be corrected. (1) No erosion protection has been provided on the upstream and downstream faces of the dam. (2) No erosion protection has been provided in the principal and emergency spillways. (3) The emergency spillway would direct high flood flows toward the toe of the embankment, which could cause erosion of the dam. (4) The principal spillway channel side slopes are steep and subject to sloughing. (5) Erosion of the exposed borrow area soils at the left abutment could cause deposition of material in the principal spillway channel. (6) The seepage and soft soil condition at the downstream toe could adversely affect the stability of the dam. (7) The small trees growing on the face of the dam could cause a potential seepage hazard. (8) The downstream slopes of the left and right sections of the dam appear to be too steep for a clay embankment. (9) Seepage and stability analyses were not available and they should be made a matter of record. (10) The combined discharge capacity of both spillways was computed to be inadequate to pass 50 percent of the Probable Maximum Flood (PMF) without significant erosion of the spillways and embankment. The PMF is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that is reasonably possible in the region. The "Recommended Guidelines for Safety Inspection of Dams" specify that the spillway design flood for this dam should be 50 to 100 percent of the PMF. However, the spillway design flood adopted for this dam is 100 percent of the PMF because the consequences of failure are serious. This dam is only about 1/2-mile from a residential area of Fredericktown, Missouri. Also, since this dam impounds water and is located immediately upstream of a tailings dam (I.D. No. 31082), failure of the Upstream Dam could cause overtopping and consequent failure of the tailings dam.

b. Adequacy of Information. No detailed design or construction data were available. Seepage and stability analyses comparable to the requirements of "Recommended Guidelines for Safety Inspection of Dams" were not available, and this lack of data is considered a deficiency.

Results of the hydrologic studies could be changed if larger scale topographic maps with smaller contour intervals were used. The only available topographic map is the 1:24,000 scale, 20-foot contour interval USGS quadrangle (AFC unedited advanced print). All measurements made on this map, such as drainage area, stream lengths, river slopes and reservoir area-capacity data, are insufficient in details, but the map suffices for the Phase I inspection. The use of the USGS quadrangle for the hydrologic studies results in an approximate evaluation of the spillway flood discharge capacity.

c. Urgency. The Phase I inspection indicated serious deficiencies in the condition of the dam and spillways. Seepage and stability analyses and measures to increase the total spillway capacity and provide the spillways with adequate erosion protection should be given priority.

d. Necessity for Phase II. No Phase II investigation is recommended; however, additional investigations are recommended as outlined in Section 7.2.g.

7.2 REMEDIAL MEASURES

The following remedial measures are recommended:

a. Adequate erosion protection should be provided in both spillway channels. The erosion protection should be adequate to withstand the peak discharge velocity resulting from the PMF.

b. The principal spillway side slopes should be laid back sufficiently so that the potential for sloughing would be minimized.

c. Measures to reduce erosion of the soils in the borrow areas should be initiated, particularly for the borrow area on the left abutment. This is necessary to limit sedimentation in the spillways.

d. The downstream channel of the emergency spillway should be directed away from the toe of the dam, i.e., in a more northerly direction.

e. Erosion protection should be provided on the downstream face of the dam. Adequate protection against wave action on the upstream face of the dam should also be provided.

f. The existing spillway capacity was calculated to be adequate to pass 12 percent of the PMF without significant erosion of the principal spillway and embankment and without overtopping the dam. To comply with the Guidelines for a dam of this size and hazard potential, the principal and emergency spillways should be enlarged and/or the freeboard increased so that the PMF can be passed without overtopping the dam crest and without significant erosion of the spillways or embankment.

g. Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of earthfill dams. Included in these analyses, computations should be performed with the reservoir water surface set at the top of the dam. The necessary data for these analyses would be obtained from additional investigations. The investigations should consist of sub-surface exploration and soil sampling and a laboratory testing program to obtain the necessary engineering parameters of the dam and foundation materials. These parameters should be used in an engineering study to evaluate the stability of the dam. Concurrent with the exploratory work, groundwater monitoring wells should be installed in the drill holes to obtain water level data that

would be used in stability studies. Remedial measures to the dam should be based on the results of the stability studies and should be done under the direction of a professional engineer experienced in earthfill dam design and construction.

h. Specific remedial work should be addressed to controlling the seepage condition at the downstream toe of the dam. This remedial work should be based on appropriate seepage analyses and should be done under the direction of an engineer experienced in earthfill dam design and construction. The engineer should also direct the removal of trees from the dam.

i. An inspection and maintenance program should be initiated. Periodic inspections should be made by qualified personnel to observe the performance of the dam and spillways. Observations should include indications of instability, such as cracks in the embankment, sloughing, erosion, sudden settlement, or an increase in the volume or turbidity of the seepage areas. It is further recommended that settlement monuments be installed on the dam crest so that crest settlement measurements can be made on a regular basis. Records should be kept of these inspections and of any corrective maintenance made to the dam and spillways.

APPENDIX A

HYDROLOGIC AND HYDRAULIC ANALYSES

The hydrologic and hydraulic analyses were accomplished by using the computer program "Flood Hydrograph Package, HEC-1, Dam Safety Investigations Version, July 1978". This program was developed by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. The criteria and methodology used are briefly discussed below:

- Probable Maximum Precipitation (PMP) - The 24-hour PMP was obtained from Hydrometeorological Report No. 33. The 6-hour and the 1-hour depth-duration distributions followed Corps of Engineers EM 1110-2-1411 criteria.

- 100-year and/or 10-year storms - The 24-hour storm amounts and distributions were supplied by Corps of Engineers, St. Louis District, Missouri.

- Unit Hydrograph - The Soil Conservation Service (SCS) curvelinear unit hydrograph method was used. Basin lag time was computed by using the SCS Curve Number Method and equation.

- Hydrologic Soil Group, Antecedent Moisture Condition (AMC) and Curve Number (CN) - The predominant hydrologic soil group for the watershed was obtained from an agricultural soil classification map prepared by the University of Missouri Agricultural Experiment Station. For the PMF and floods expressed as a percent of PMF, AMC III conditions were used. For the 100-year and/or 10-year floods, AMC II conditions were assumed. Watershed CN was estimated from field observations and from aerial photos.

- Reservoir Area-Capacity - Areas were measured from U.S.G.S. topographic maps. Reservoir elevations and corresponding surface areas were input in the computer program, which determined the reservoir capacities by the Conic Method.

- Reservoir and Spillway Flood Routing - The Modified Puls Method was used for all flood routing through spillway and dam overtopping analyses.

The following pages present the input data listing, the computer program version and its last modification date, together with pertinent computer printouts of results. Definitions of all input and output variable names are presented in the computer program "Users Manual", September 1978, and are not explained herein.

```
A1          ANSCHUTZ      DAM MO. NO. 31080
A2          HEC-1  PHASE 1  DAM SAFETY INVESTIGATIONS
A3          RATIOS OF PMF ROUTED THROUGH RESERVOIR
B     144                   10                                                    2
B1      5.
J       1         4         1
J1    .25       .50       .75       1.0
K       0  INFLOW                                1         1
M       1         2     .3625                               1                    1
P       0      26.5       102       120       130
T                                                                  -1       -70                .1
W2                .6
X     -10        -.1       2.5
K       1  LAKE                                 2         1
Y                                          1         1
Y1      1                                                          -856.0       -1
Y4  856.0     857.1     858.4     859.7     861.0     863.0     863.9     864.5     865.0     866.5
Y5      0         9        63       161       291       635       840      1106      1579      5713
$A      0         5      12.5        19        23      28.4      38.7        59
$E    830       840       850       856       860     863.8       870       880
$S  856.0
$D  863.8
K      99
A
A
A
A
A
```

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

RUN  DATE= 79/07/13.
     TIME= 13.29.30.
```

ANSCHUTZ DAM NO. NO. 31080
HEC-1 PHASE 1 DAM SAFETY INVESTIGATIONS
RATIOS OF PMF ROUTED THROUGH RESERVOIR

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
144	0	10	0	0	0	0	0	2	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 4 LRTIO= 1
RTIOS= .25 .50 .75 1.00

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

SUB-AREA RUNOFF COMPUTATION

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

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.36	0.00	.36	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	26.50	102.00	120.00	130.00	0.00	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	-70.00	0.00	.10

CURVE NO = -70.00 WETNESS = -1.00 EFFECT CN = 70.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .60

RECESSION DATA
STRTQ= -10.00 QRCSN= -.10 RTIOR= 2.50

UNIT HYDROGRAPH 20 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .60 VOL= 1.00

36.	116.	220.	256.	235.	184.	117.	78.	54.	36.
24.	16.	11.	7.	5.	3.	2.	2.	1.	0.

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q

1.01	.10	1	.03	.00	.03	3.	1.01	12.10	73	.45	.37	.08	155.
1.01	.20	2	.03	.00	.03	3.	1.01	12.20	74	.45	.38	.08	186.
1.01	.30	3	.03	.00	.03	4.	1.01	12.30	75	.45	.38	.07	246.
1.01	.40	4	.03	.00	.03	4.	1.01	12.40	76	.45	.39	.06	316.
1.01	.50	5	.03	.00	.03	5.	1.01	12.50	77	.45	.39	.06	382.
1.01	1.00	6	.03	.00	.03	5.	1.01	13.00	78	.45	.40	.05	435.
1.01	1.10	7	.03	.00	.03	5.	1.01	13.10	79	.58	.48	.06	475.
1.01	1.20	8	.03	.00	.03	5.	1.01	13.20	80	.54	.49	.05	511.
1.01	1.30	9	.03	.00	.03	5.	1.01	13.30	81	.54	.49	.05	549.
1.01	1.40	10	.03	.00	.03	5.	1.01	13.40	82	.54	.49	.05	585.
1.01	1.50	11	.03	.00	.03	5.	1.01	13.50	83	.54	.50	.04	617.
1.01	2.00	12	.03	.00	.03	5.	1.01	14.00	84	.54	.50	.04	642.
1.01	2.10	13	.03	.00	.03	5.	1.01	14.10	85	.68	.63	.05	668.
1.01	2.20	14	.03	.00	.03	5.	1.01	14.20	86	.68	.63	.04	693.
1.01	2.30	15	.03	.00	.03	5.	1.01	14.30	87	.68	.64	.04	731.
1.01	2.40	16	.03	.00	.03	5.	1.01	14.40	88	.68	.64	.04	772.
1.01	2.50	17	.03	.00	.03	5.	1.01	14.50	89	.68	.64	.03	809.
1.01	3.00	18	.03	.00	.03	5.	1.01	15.00	90	.68	.64	.03	839.
1.01	3.10	19	.03	.00	.03	5.	1.01	15.10	91	.62	.59	.03	857.
1.01	3.20	20	.03	.00	.03	5.	1.01	15.20	92	1.03	.99	.04	879.
1.01	3.30	21	.03	.00	.03	5.	1.01	15.30	93	1.85	1.78	.06	951.
1.01	3.40	22	.03	.00	.03	5.	1.01	15.40	94	4.62	4.50	.12	1221.
1.01	3.50	23	.03	.00	.03	5.	1.01	15.50	95	1.34	1.31	.03	1689.
1.01	4.00	24	.03	.00	.03	5.	1.01	16.00	96	.82	.81	.02	2189.
1.01	4.10	25	.03	.00	.03	4.	1.01	16.10	97	.63	.62	.01	2376.
1.01	4.20	26	.03	.00	.03	4.	1.01	16.20	98	.63	.62	.01	2255.
1.01	4.30	27	.03	.00	.03	4.	1.01	16.30	99	.63	.62	.01	1957.
1.01	4.40	28	.03	.00	.03	4.	1.01	16.40	100	.63	.62	.01	1603.
1.01	4.50	29	.03	.00	.03	4.	1.01	16.50	101	.63	.62	.01	1362.
1.01	5.00	30	.03	.00	.03	4.	1.01	17.00	102	.63	.62	.01	1204.
1.01	5.10	31	.03	.00	.03	4.	1.01	17.10	103	.50	.49	.01	1089.
1.01	5.20	32	.03	.00	.03	4.	1.01	17.20	104	.50	.49	.01	1002.
1.01	5.30	33	.03	.00	.03	5.	1.01	17.30	105	.50	.49	.01	925.
1.01	5.40	34	.03	.00	.02	5.	1.01	17.40	106	.50	.49	.01	856.
1.01	5.50	35	.03	.00	.02	5.	1.01	17.50	107	.50	.49	.01	802.
1.01	6.00	36	.03	.01	.02	6.	1.01	18.00	108	.50	.49	.01	763.
1.01	6.10	37	.13	.03	.11	7.	1.01	18.10	109	.04	.04	.00	722.
1.01	6.20	38	.13	.03	.10	10.	1.01	18.20	110	.04	.04	.00	654.
1.01	6.30	39	.13	.04	.09	16.	1.01	18.30	111	.04	.04	.00	545.
1.01	6.40	40	.13	.04	.09	24.	1.01	18.40	112	.04	.04	.00	422.
1.01	6.50	41	.13	.05	.08	32.	1.01	18.50	113	.04	.04	.00	310.
1.01	7.00	42	.13	.05	.08	41.	1.01	19.00	114	.04	.04	.00	234.
1.01	7.10	43	.13	.06	.08	49.	1.01	19.10	115	.04	.04	.00	214.
1.01	7.20	44	.13	.06	.07	56.	1.01	19.20	116	.04	.04	.00	195.
1.01	7.30	45	.13	.06	.07	63.	1.01	19.30	117	.04	.04	.00	178.
1.01	7.40	46	.13	.07	.07	69.	1.01	19.40	118	.04	.04	.00	162.
1.01	7.50	47	.13	.07	.06	75.	1.01	19.50	119	.04	.04	.00	148.
1.01	8.00	48	.13	.07	.06	80.	1.01	20.00	120	.04	.04	.00	135.
1.01	8.10	49	.13	.07	.06	86.	1.01	20.10	121	.04	.04	.00	123.
1.01	8.20	50	.13	.08	.06	90.	1.01	20.20	122	.04	.04	.00	113.
1.01	8.30	51	.13	.08	.05	95.	1.01	20.30	123	.04	.04	.00	103.
1.01	8.40	52	.13	.08	.05	99.	1.01	20.40	124	.04	.04	.00	98.
1.01	8.50	53	.13	.08	.05	102.	1.01	20.50	125	.04	.04	.00	86.
1.01	9.00	54	.13	.09	.05	106.	1.01	21.00	126	.04	.04	.00	78.
1.01	9.10	55	.13	.09	.05	109.	1.01	21.10	127	.04	.04	.00	71.
1.01	9.20	56	.13	.09	.04	112.	1.01	21.20	128	.04	.04	.00	65.
1.01	9.30	57	.13	.09	.04	115.	1.01	21.30	129	.04	.04	.00	61.
1.01	9.40	58	.13	.09	.04	118.	1.01	21.40	130	.04	.04	.00	61.
1.01	9.50	59	.13	.09	.04	121.	1.01	21.50	131	.04	.04	.00	61.

1.01	10.00	60	.13	.09	.04	123.	1.01	22.00	132	.04	.04	.00	61.
1.01	10.10	61	.13	.10	.04	126.	1.01	22.10	133	.04	.04	.00	61.
1.01	10.20	62	.13	.10	.04	128.	1.01	22.20	134	.04	.04	.00	61.
1.01	10.30	63	.13	.10	.03	130.	1.01	22.30	135	.04	.04	.00	61.
1.01	10.40	64	.13	.10	.03	132.	1.01	22.40	136	.04	.04	.00	61.
1.01	10.50	65	.13	.10	.03	134.	1.01	22.50	137	.04	.04	.00	61.
1.01	11.00	66	.13	.10	.03	135.	1.01	23.00	138	.04	.04	.00	61.
1.01	11.10	67	.13	.10	.03	137.	1.01	23.10	139	.04	.04	.00	61.
1.01	11.20	68	.13	.10	.03	139.	1.01	23.20	140	.04	.04	.00	61.
1.01	11.30	69	.13	.10	.03	140.	1.01	23.30	141	.04	.04	.00	61.
1.01	11.40	70	.13	.11	.03	142.	1.01	23.40	142	.04	.04	.00	61.
1.01	11.50	71	.13	.11	.03	143.	1.01	23.50	143	.04	.04	.00	61.
1.01	12.00	72	.13	.11	.03	144.	1.02	0.00	144	.04	.04	.00	61.
									SUM	34.45	30.26	4.19	42808.
										(875.)(	769.)(	106.)(	1212.19)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2376.	972.	297.	297.	42788.
CMS	67.	28.	8.	8.	1212.
INCHES		24.94	30.50	30.50	30.50
MM		633.53	774.63	774.63	774.63
AC-FT		482.	589.	589.	589.
THOUS CU M		594.	727.	727.	727.

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

HYDROGRAPH ROUTING

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
LAKE	1	0	0	2	1	0	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-856.	-1

STAGE	856.00	857.10	858.40	859.70	861.00	863.00	863.90	864.50	865.00	866.50
FLOW	0.00	9.00	63.00	161.00	291.00	635.00	840.00	1106.00	1579.00	5713.00
SURFACE AREA=	0.	5.	13.	19.	23.	28.	39.	59.		
CAPACITY=	0.	17.	101.	195.	279.	377.	584.	1069.		
ELEVATION=	830.	840.	850.	856.	860.	864.	870.	880.		

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPI
856.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
863.8	0.0	0.0	0.

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 .25	RATIO 2 .50	RATIO 3 .75	RATIO 4 1.00
HYDROGRAPH AT	INFLOW	.36	1	594.	1188.	1782.	2376.
	(	.94)	(	16.82)(	33.63)(	50.45)(	67.27)(
ROUTED TO	LAKE	.36	1	206.	546.	971.	1781.
	(	.94)	(	5.82)(	15.45)(	27.49)(	50.42)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	856.00	856.00	863.80
STORAGE	195.	195.	377.
OUTFLOW	0.	0.	817.

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
.25	860.15	0.00	282.	206.	0.00	17.83	0.00
.50	862.48	0.00	340.	546.	0.00	17.17	0.00
.75	864.20	.40	388.	971.	1.33	16.83	0.00
1.00	865.07	1.27	414.	1781.	2.50	16.50	0.00

APPENDIX B
INFORMATION SUPPLIED BY OTHERS

ENGINEERING GEOLOGIC REPORT ON THE SILAS DEES (FORMERLY NATIONAL LEAD TAILINGS) PONDS

MADISON COUNTY, MISSOURI 11/15/77

LOCATION: Southwest of Fredericktown on Toler Creek.

The structure investigated is an old tailings pond used by National Lead Company during the period in which the mine at this site was in operation. The structure is located southeast of the city of Fredericktown on Toler Creek. A second dam exists upstream of this structure which was a clear water impoundment. A third structure is a tailing dam to the northeast of the first structure and drains into the first or lower tailings pond through a culvert. The lower tailings pond is of primary interest here.

The lower tailings pond reportedly was breached in the 1950's and was rebuilt. This structure failed in the spring of 1977 (see previous report by Tom Dean). The structure was again rebuilt during the summer-fall of 1977, and is presently owned by Mr. Silas Dees. The dam of the tailings pond consists of an earthen embankment overgrown with trees and brush, and a dike composed principally of tailings. The dam was breached to the approximate grade of Toler Creek after the spring 1977 failure.

On November 9, 1977 the site was revisited by Jon Bennett and the undersigned to inspect the newly repaired structures. At the time of visit, the lower structure had been filled with stoney clay which was quite soft. A pipe approximately 8 inches in diameter was dribbling water as was the not quite completely filled in breach fill. A photograph labeled 1 shows Jon Bennett beside the pipe. Toler Creek showed a larger flow than the pipe and water flowing down the dam.

Above this fill were large cracks in the fill, one of which had eroded to a sag pond which was draining into it (see photograph 2). The sag ponds were particularly interesting owing to their size (see photograph 3) and lack of surface drainage into them, yet there was significant, continual discharge. Jon Bennett reported seeing air bubbles come up from the bottom of the sag ponds. The larger of the ponds discharged over the downstream side of the dam. Both of the sag ponds described discharged continually during our visit.

The tailings dike had been filled with stoney red clay. Cracks parallel to the dam axis were observed on the stoney clay fill on either side of the dam. However, only the dike has been filled with soil, the semi-consolidated "slime" or tailings which were eroded to the approximate depth of Toler Creek were not refilled. water now stands in this rather large gap to the height of the tailings. There was no indication of the pipe which is on the downstream side of the dam. Photograph 4 shows the height of the dam at the repaired breach and the sharp drop off at the tailings water interface.

The spillway has been cleared and will conduct a small amount of water when the water height is within about four to five feet of the crest of the dam. Photographs 5 and 6 show the height and width of the spillway which empties into Toler Creek. The dam appears to be higher at the spillway than in the center of the dam (compare photographs 4, 5 and 6).

The decant structure located in the east central portion of the tailings (see map) was filled with trees, limbs and debris. A one and one half foot lateral dike across the slime pond was rebuilt conducting about one half of all surface runoff to the clogged drop inlet of the decant structure.

The upper "clear water" structure had been breached prior to the time of the spring 1977 lower dam failure. The breached area has been since filled in. The limits of the breached area and former crest of the dam are delineated by vegetal growth and small trees which have been covered by newly laid stoney red clay.

The slopes are steep on either side of the structure. There is little evidence of construction work near the base of the dam.

The spillway is quite long in that it winds above the south shoreline. It is choked with many small to well established pine trees. Small slides, erosion, etc. have caused the spillway elevations to rise and fall. Three small ponds exist where the spillway race crosses small drainages.

Only a small amount of water was impounded by the structure in spite of the considerable rainfall during previous weeks.

CONCLUSIONS:

The lower dam allows seepage through the tailings dike and earthen embankment. The vegetal growth, saturated soils, sag ponds and other factors indicate a lack of acceptable construction practices utilized in the rebuilding of the lower dam. Given these conditions, failure of the lower dam seems imminent. It is recommended that an engineer experienced in dam design and construction be consulted by the owner at an early date.

The presence of vegetation covered by soil, steep slopes, overgrowth in spillway and other factors suggest that this structure may not have been built utilizing acceptable construction practices. A review of construction plans and procedures by an engineer experienced in the design and construction of dams would be in order.

Christopher J. Stohr, Geologist
Applied Engineering & Urban Geology
Geology & Land Survey
November 15, 1977

PHOTO 1xm-129 FLOWN, 1971 CROP YEAR

ADDENDUM TO FREDRICKTOWN, nee NATIONAL LEAD, nee DEES TAILINGS DAM

MADISON COUNTY, MISSOURI

Site visit on 7 February 1978 by T. Dean, G. St. Ivany, and Jim Williams, Div. of Geology and Land Survey, and Jon Bennett, City Administrator, Fredericktown, Mo. Sketch of site on Figs. 1 and 2 attached.

The gorge that had eroded after the 1977 failure is now plugged with fill dirt. This gorge has an approximate maximum depth of 35 feet. The dike averages 4-5 feet high except for the 35 foot high fill in the gorge. The gorge has been eroded to the downstream floodplain level. The material filling the gorge is tailings and dirt. Slopes are 1¼:1 to 1 3/4:1. The crest width is 10 feet. Cracks are developing in the fill.

The sag pond behind the gorge fill is partially filled. Dirt previously dumped into the old breach of the sag pond has been partially removed to allow drainage from the sag pond.

A pipe discharge at the base of tailings at floodplain level was observable. This 8-inch pipe was placed end to end-not coupled. Water seeps around the pipe. The extent and means of placement of the pipe back under the filled gorge are unknown. The gorge is one-half to two-thirds filled with water.

The drop inlet (decant inlet) is 2 feet above the level of the fill at the gorge. The decant is partially filled with broken timber. The discharge pipe appears to be 4 feet in diameter. It's condition is unknown.

The emergency spillway at the left of the main stilling basin has 3 feet of freeboard below the decant inlet. This is based on hand level observation.

The upstream fresh water dam breach reportedly has been filled by end dumping (Pers. Comm.) off the edges of the crest of the breached dam. The contact between the old and new dirt is steep. However, no differential settlement has occurred. The fill dirt is a gravelly silty clay. The fill was completed in October, 1977.

The spillway is a tortuous ditch with trees and brush that eventually discharges downstream of the main stilling basin. It is a "V" shaped ditch, 20 feet at the top of the "V". The dam has 3 feet of freeboard at the high point of the ditch spillway. This is some 600 feet from the inlet. Here the spillway could also breach and discharge to the main stilling basin.

The hazards in order of priority are:

1) Collapse of fill across the 35-foot gorge with catastrophic discharge of water from the gorge and main stilling basin.

2) Differential settlement and failure of fill dirt placed in the breach of the upstream fresh water dam.

3) Failure of decant spillway due to plugging.

4) Problem of the fresh water dam spillway to handle flood discharges. Approximate calculations indicate spillway could not carry peak runoff from a 25 year storm. However, a calculated storm has not been routed through the spillway. Also, the dam has 5 feet of freeboard. Thus, this storage together with spillway capacity places overtopping possibilities as the least of the hazards at the Fredericktown Tailings Ponds.

The collapse of the gorge fill is likely to occur. The first intense rain this spring could easily cause that. Damage in Fredericktown would be significant.

Dr. J. Hadley Williams, Chief
Applied Engineering & Urban Geology
Geology & Land Survey
February 14, 1978

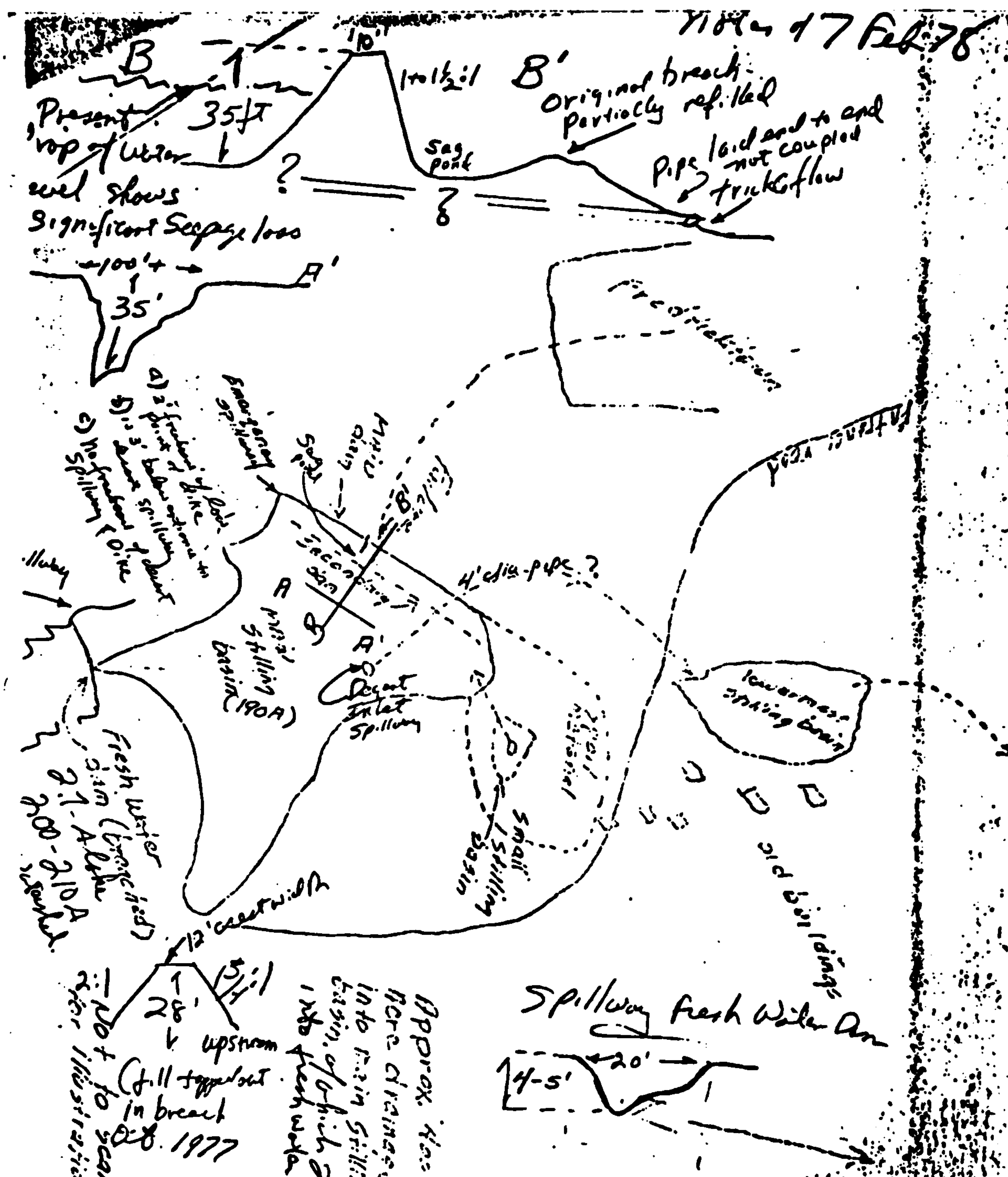
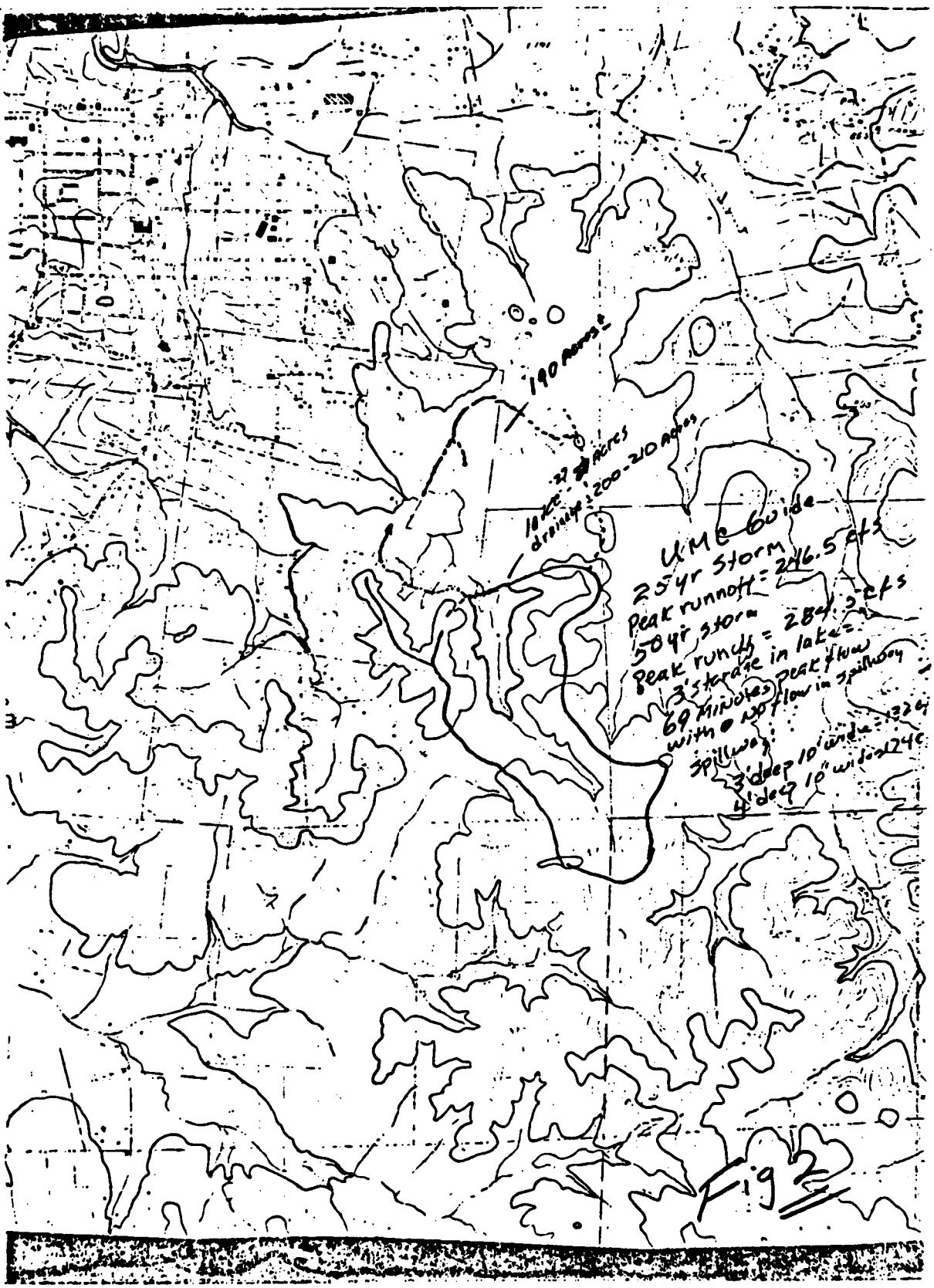
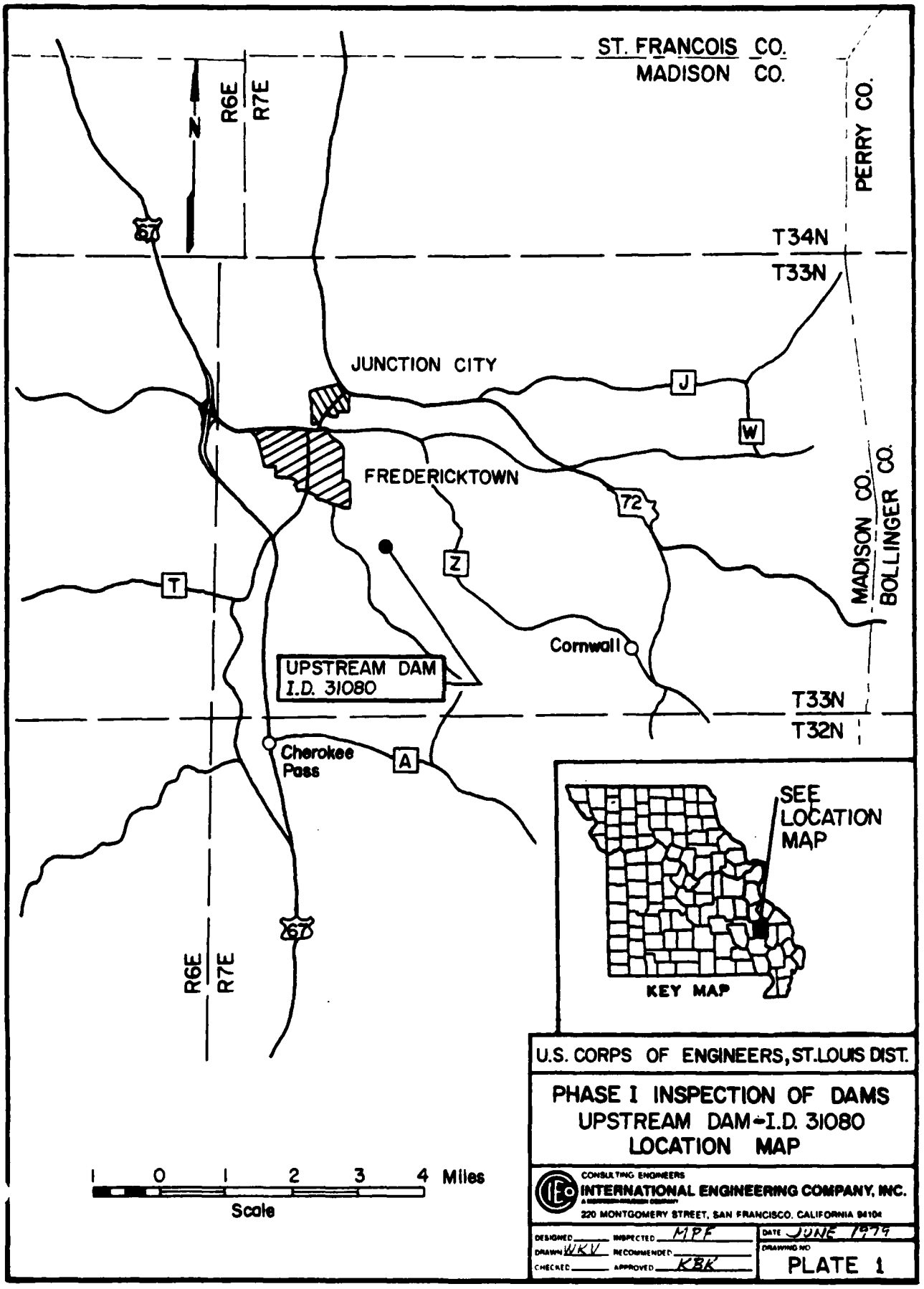
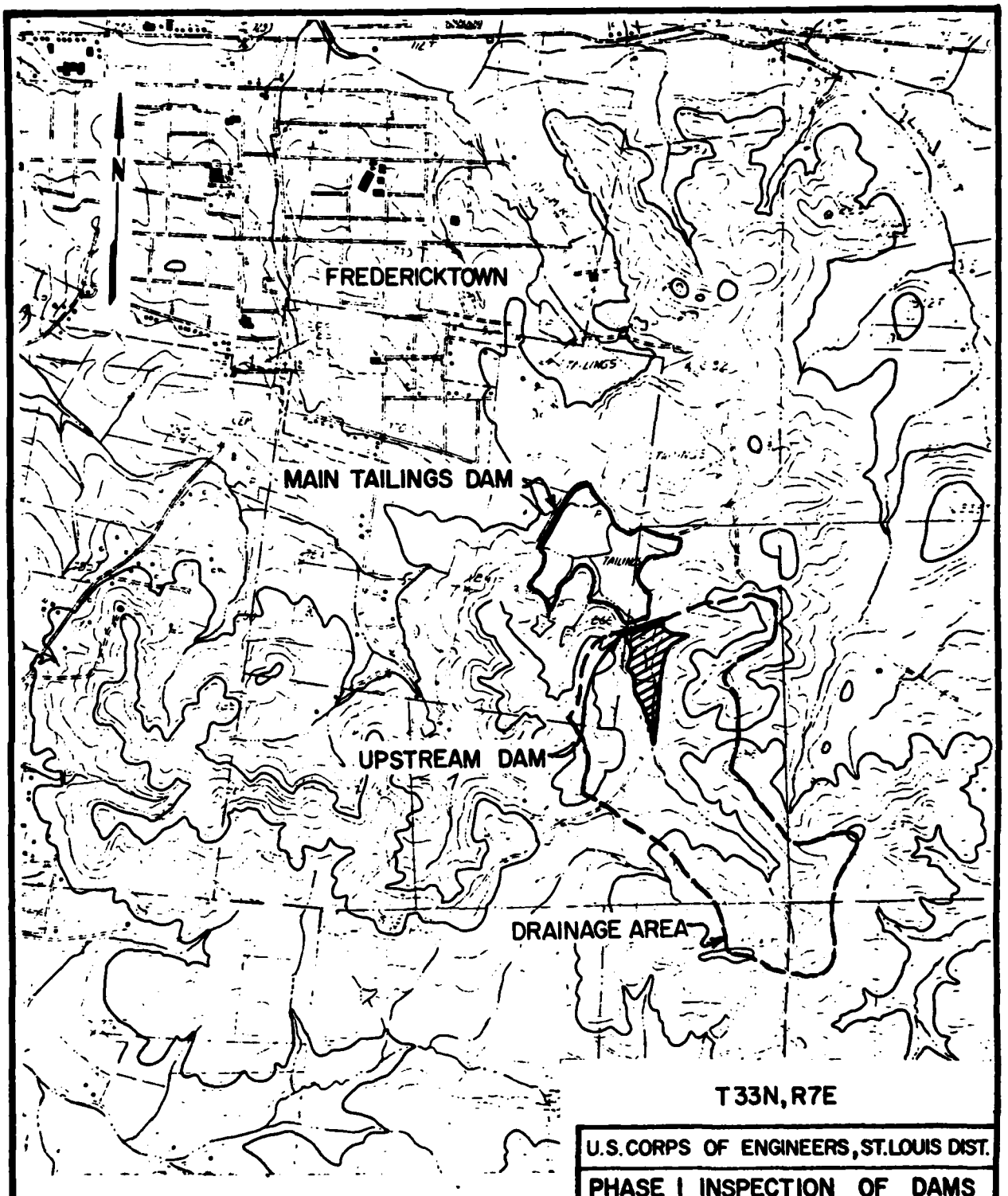

B
B'
35 ft
10'
Original breach partially refilled
Sag pond
Pipe laid end to end not coupled
trickle flow
Present top of water level shows significant seepage loss
100'±
35'
A'
Emergency Spillway
Main Stilling basin (190A)
Outlet Inlet Spillway
4' dia pipe ?
Small Stilling basin
lowermost stilling basin
old buildings
Spillway Fresh Water Dam
20'
4-5'
12' crest width
28'
2:1
3:1
upstream
Not to scale for illustration
Approx. 4 acre drainage into main stilling basin
Fresh water dam

Fig 1


190 Acres
drainage = 200-210 Acres
UME 60 side
25yr storm
peak runnoff = 246.5 cfs
50yr storm
peak runoff = 284.3 cfs
3' storage in lake =
69 Minutes peak flow
with no flow in spillway
spillway:
3' deep 10' wide = 324
4' deep 10' wide = 240
Fig 2


ST. FRANCOIS CO.
MADISON CO.
PERRY CO.
R6E
R7E
N
67
T34N
T33N
JUNCTION CITY
J
W
FREDERICKTOWN
72
Z
T
MADISON CO.
BOLLINGER CO.
Cornwall
UPSTREAM DAM
I.D. 31080
T33N
T32N
Cherokee
Pass
A
67
R6E
R7E
0 1 2 3 4 Miles
Scale
SEE
LOCATION
MAP
KEY MAP
U.S. CORPS OF ENGINEERS, ST.LOUIS DIST.
PHASE I INSPECTION OF DAMS
UPSTREAM DAM - I.D. 31080
LOCATION MAP
CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET, SAN FRANCISCO, CALIFORNIA 94104
DESIGNED
DRAWN WKV
CHECKED
INSPECTED MPF
RECOMMENDED
APPROVED KBK
DATE JUNE 1979
DRAWING NO
PLATE 1



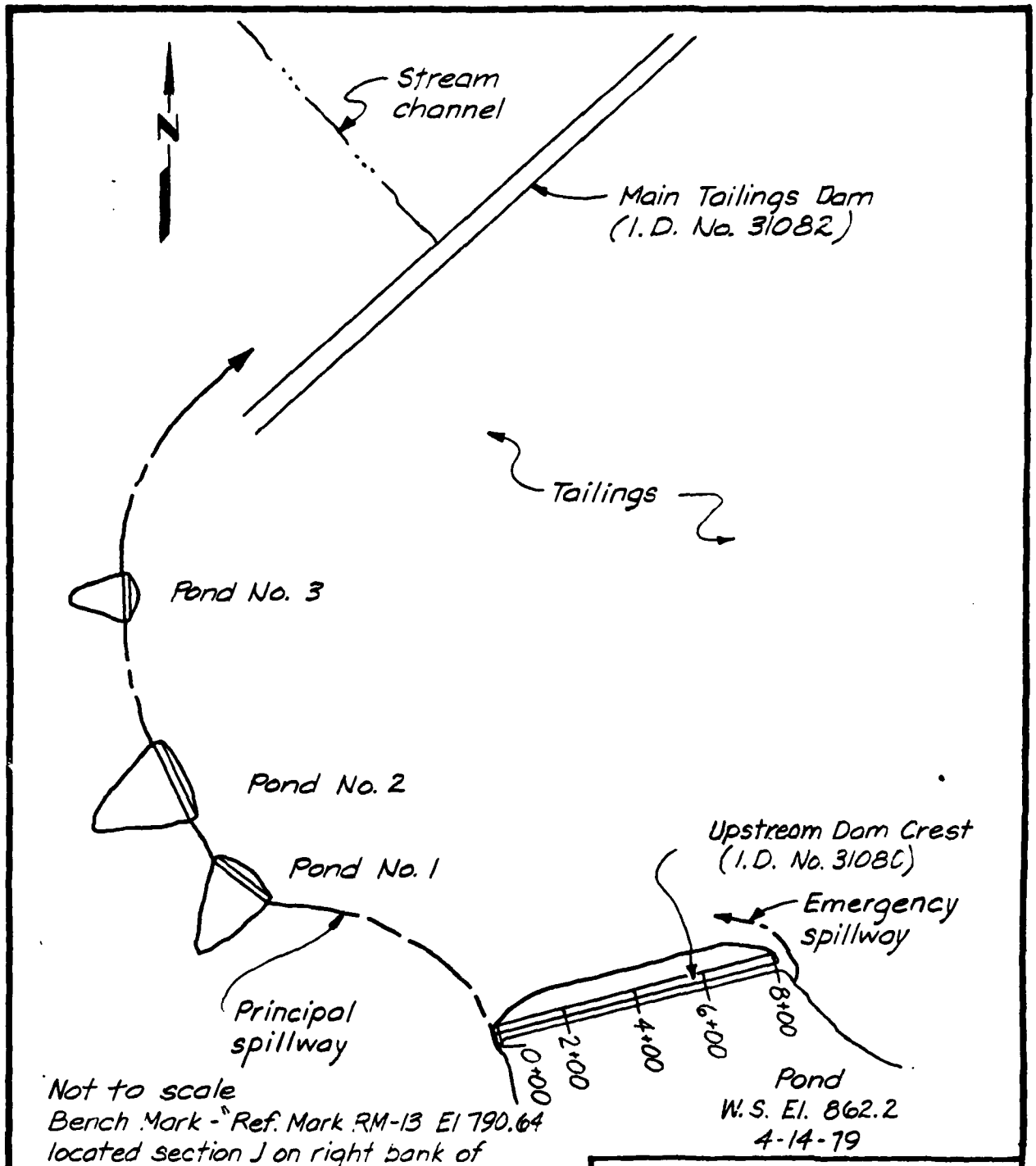
U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

PHASE I INSPECTION OF DAMS
UPSTREAM DAM - I.D. 31080
VICINITY TOPOGRAPHY

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET, SAN FRANCISCO, CALIFORNIA 94104

DESIGNED ____ INSPECTED PAPF
DRAWN WRV RECOMMENDED ____
CHECKED ____ APPROVED KBK
DATE JUNE 197_

PLATE 2



Not to scale

Bench Mark - "Ref. Mark RM-13 El 790.64 located section J on right bank of Toler Creek 20' south of where road turns east. Spike 0.5' above ground on north face of power pole 027."

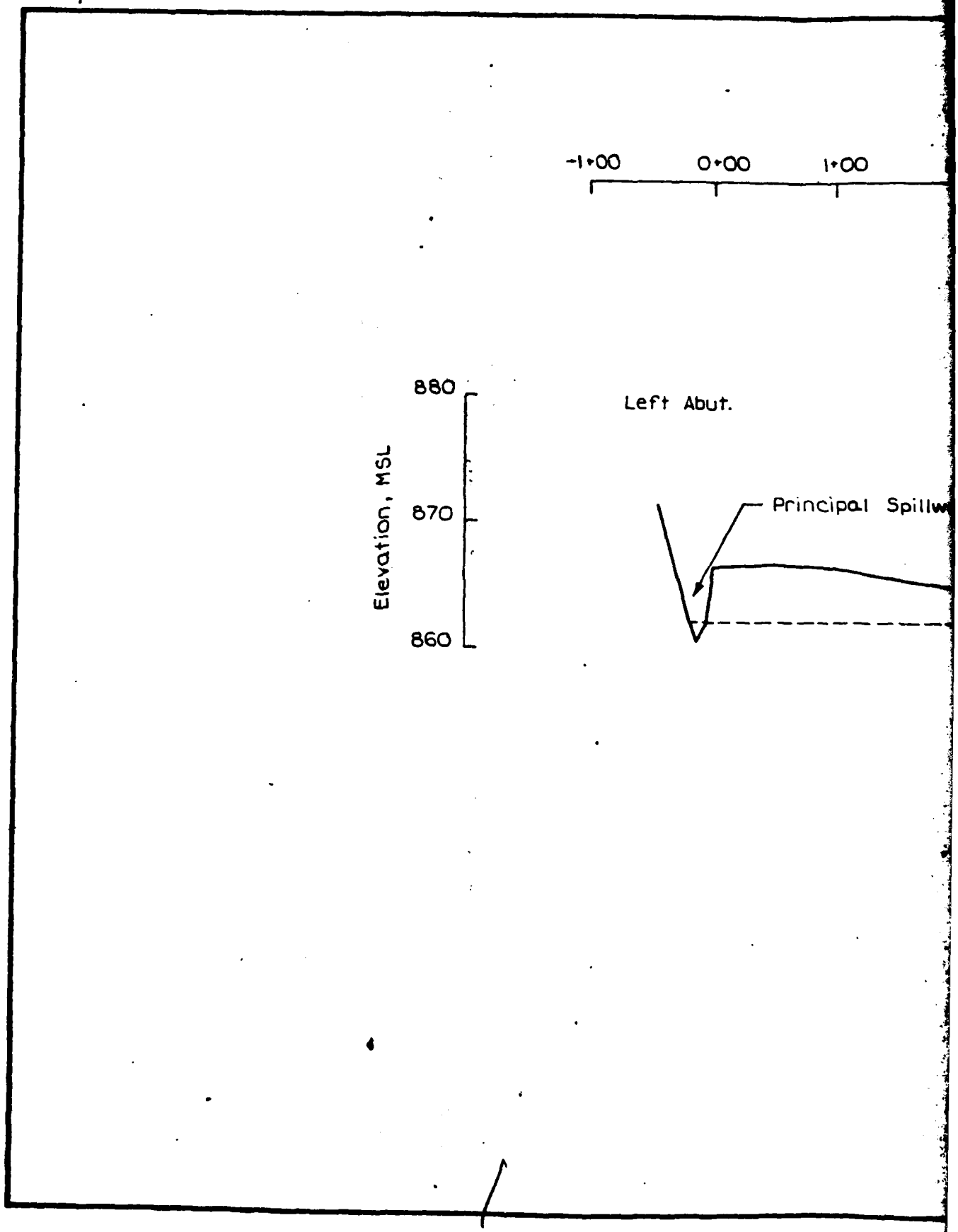
Date of Survey: 4-14-79 and 4-18-79
Survey by Memphis District, Corps of Engineers. See Plates 4-8.

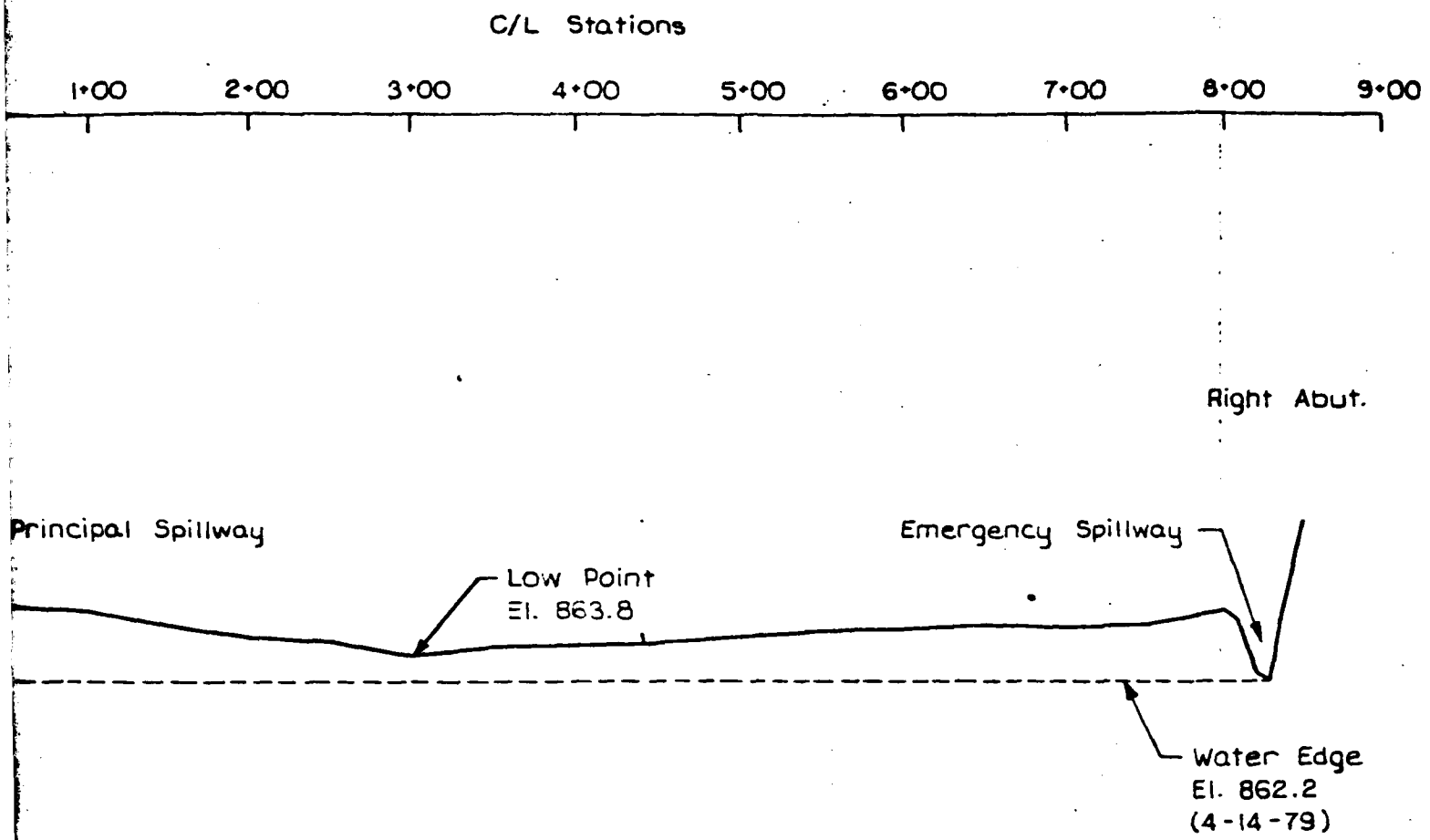
U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

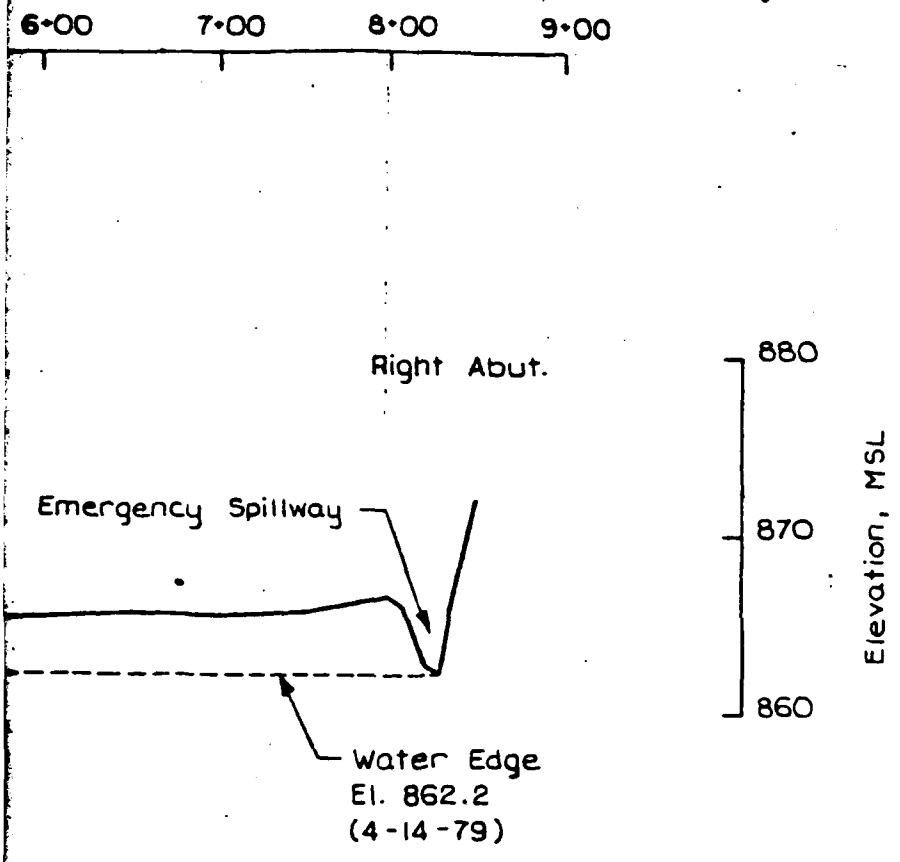
PHASE I INSPECTION OF DAMS
UPSTREAM DAM - I.D. NO. 31080
PLAN

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET, SAN FRANCISCO, CALIFORNIA 94104

DESIGNED	INSPECTED MPF	DATE JUNE 22 79
DRAWN WK.V.	RECOMMENDED	DRAWING NO.
CHECKED	APPROVED KBK	PLATE 3


-1+00
0+00
1+00
880
870
860
Elevation, MSL
Left Abut.
Principal Spillw


C/L Stations
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
Right Abut.
Principal Spillway
Emergency Spillway
Low Point
El. 863.8
Water Edge
El. 862.2
(4-14-79)



ALL ELEVATIONS ARE FEET ABOVE MEAN SEA LEVEL

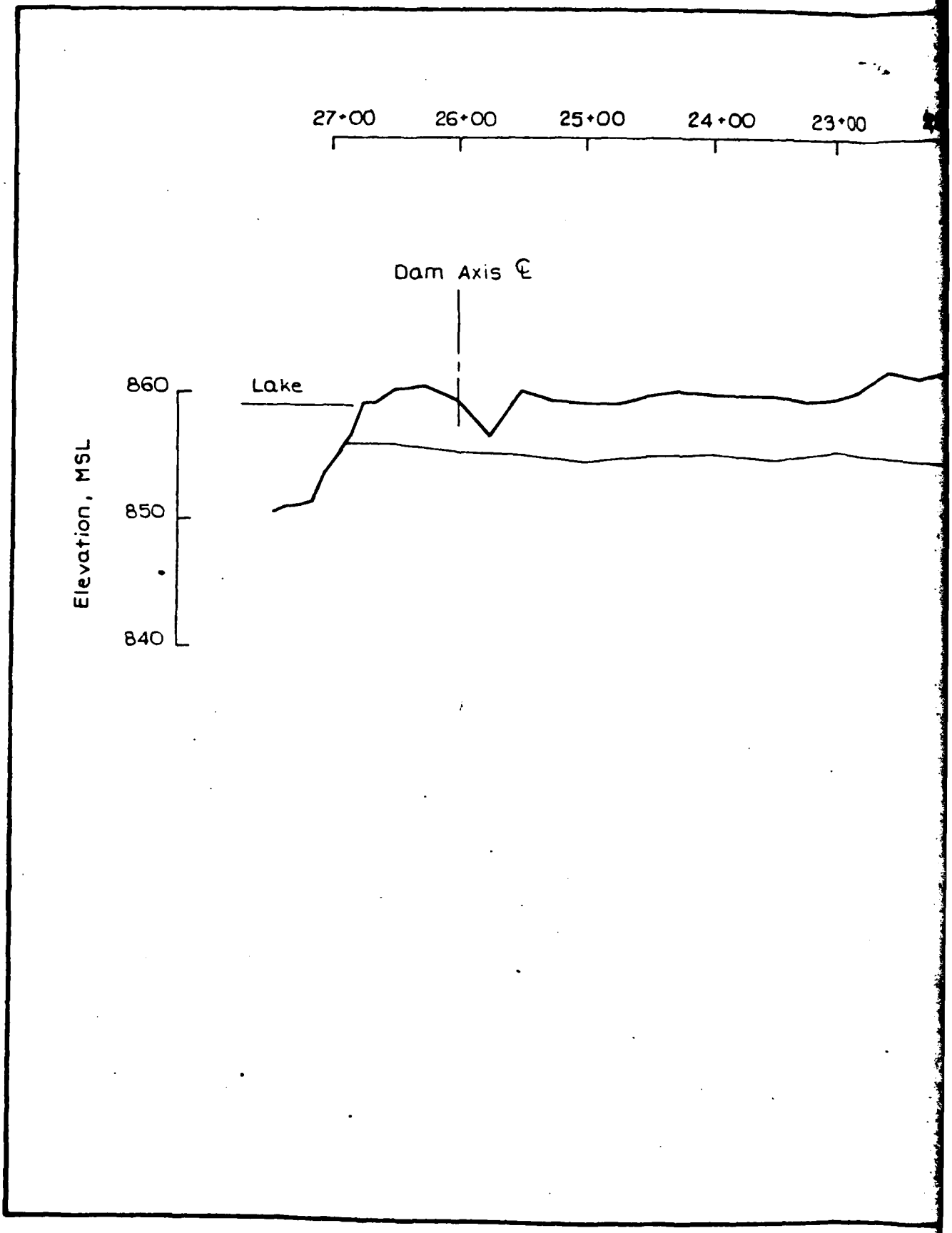
MISSISSIPPI RIVER AND TRIBUTARIES

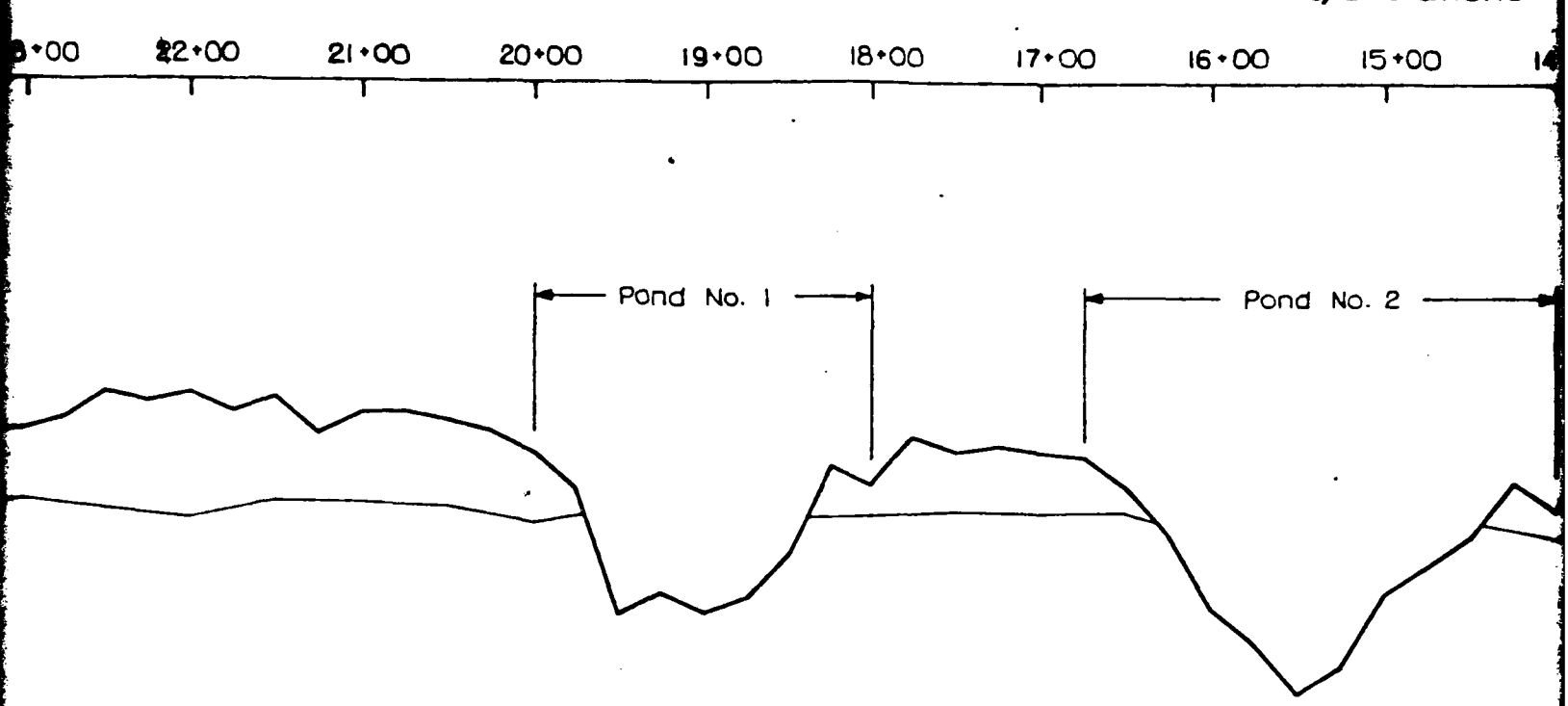
MO 31080

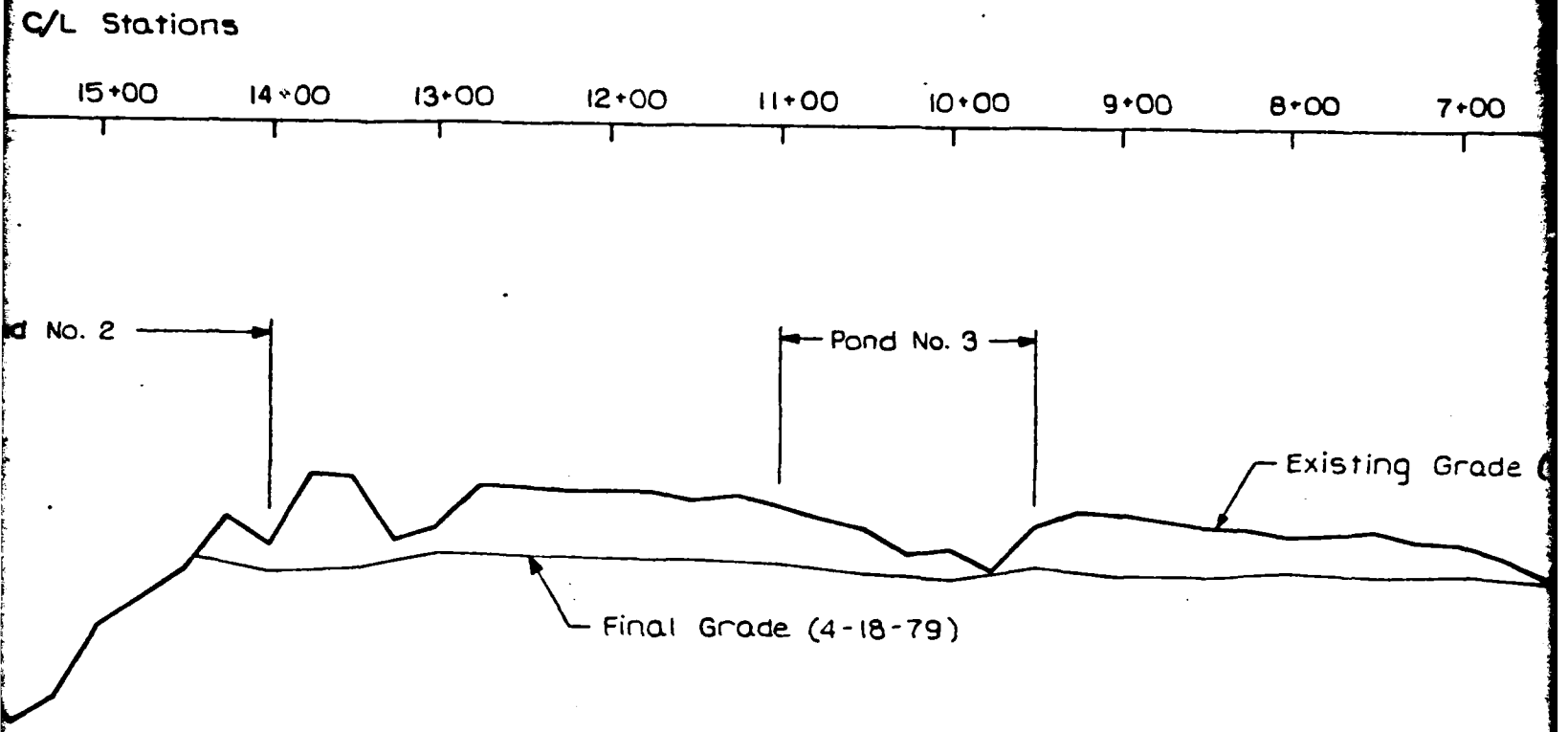
EMBANKMENT CENTERLINE PROFILE

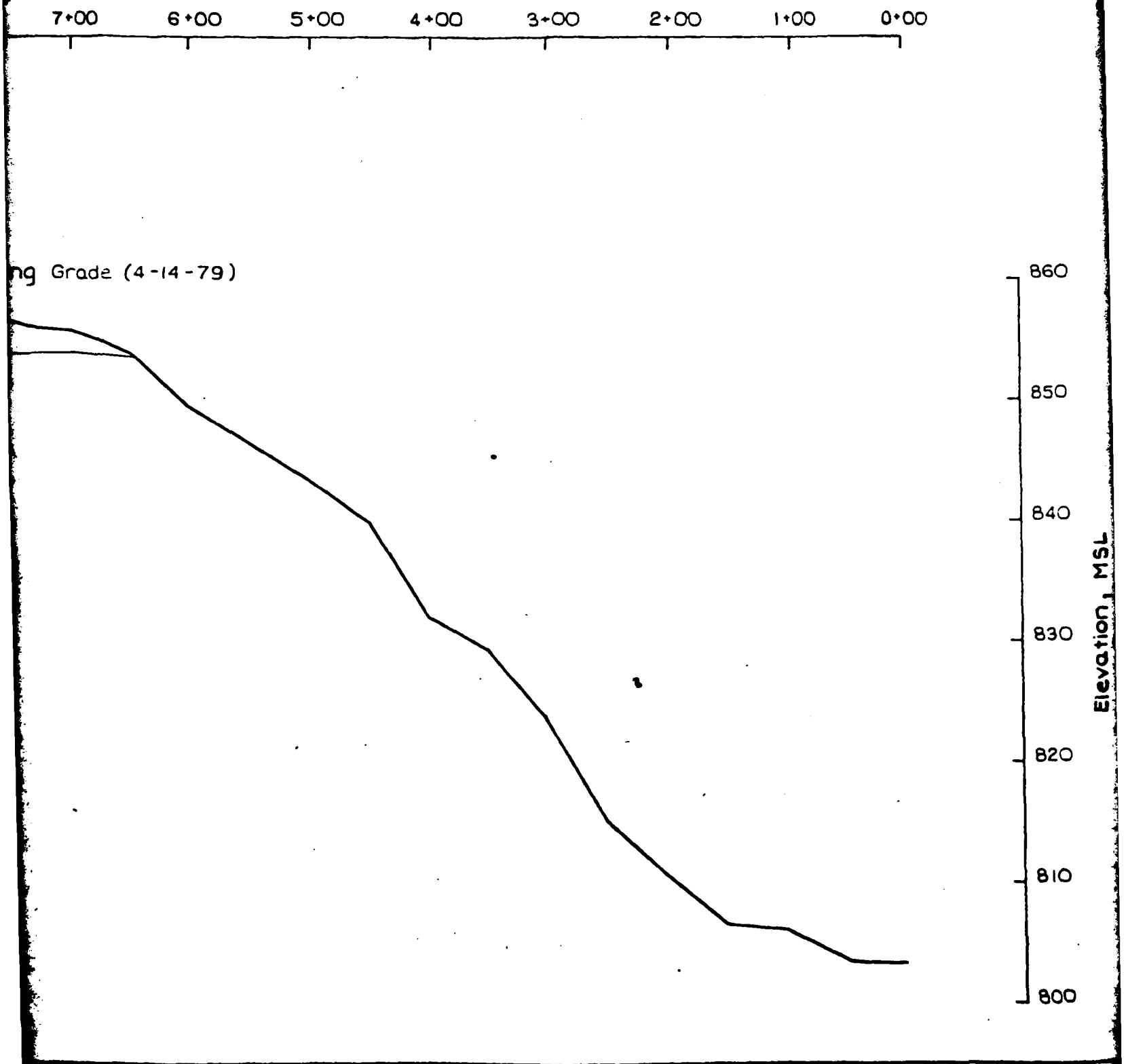
DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT, CORPS OF ENGINEERS
TO ACCOMPANY DESIGN MEMORANDUM NO.
DATE. SERIAL. FILE.

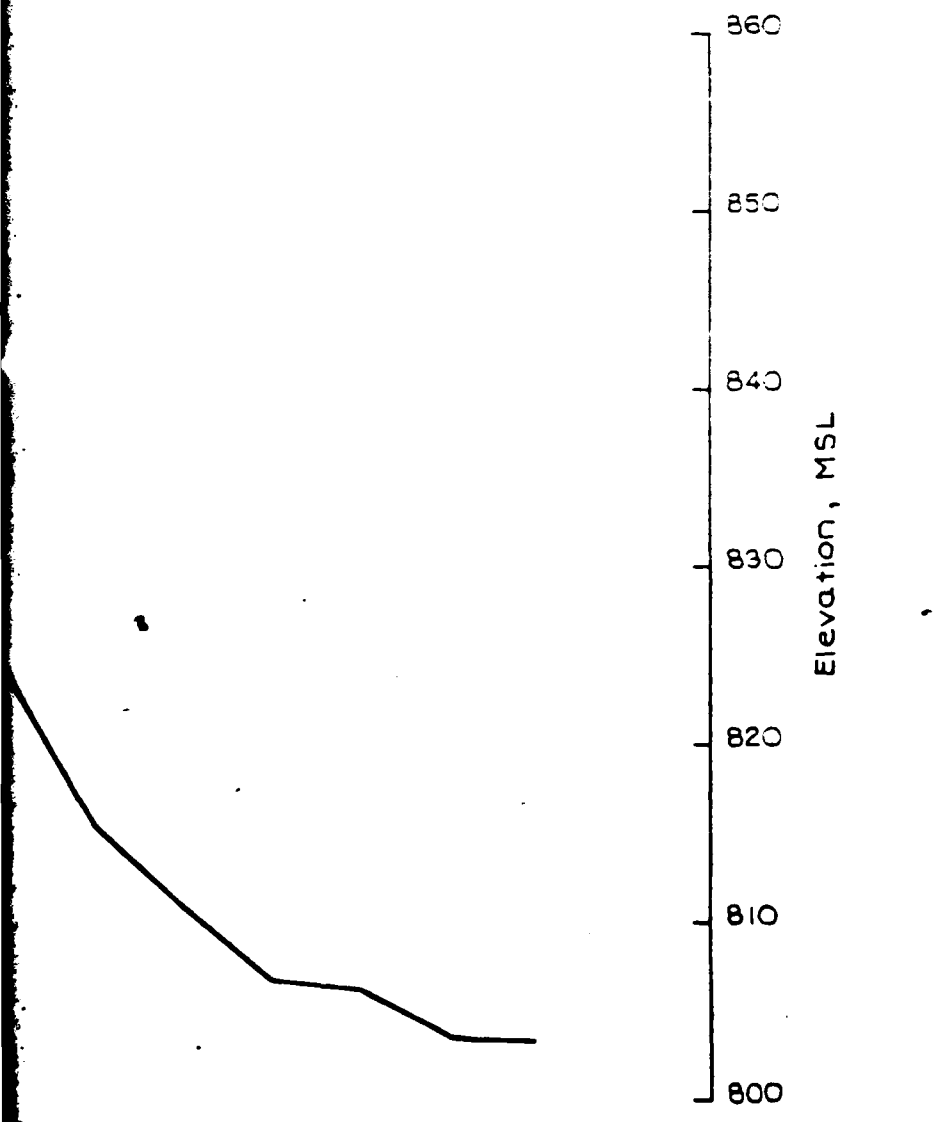
PLATE 4


27+00
26+00
25+00
24+00
23+00
Dam Axis ℄
Lake
860
850
840
Elevation, MSL


C/L Stations
23+00
22+00
21+00
20+00
19+00
18+00
17+00
16+00
15+00
14
Pond No. 1
Pond No. 2


C/L Stations
15+00
14+00
13+00
12+00
11+00
10+00
9+00
8+00
7+00
d No. 2
Pond No. 3
Existing Grade
Final Grade (4-18-79)


7+00
6+00
5+00
4+00
3+00
2+00
1+00
0+00
ng Grade (4-14-79)
860
850
840
830
820
810
800
Elevation, MSL



ALL ELEVATIONS ARE FEET ABOVE MEAN SEA LEVEL

MISSISSIPPI RIVER AND TRIBUTARIES

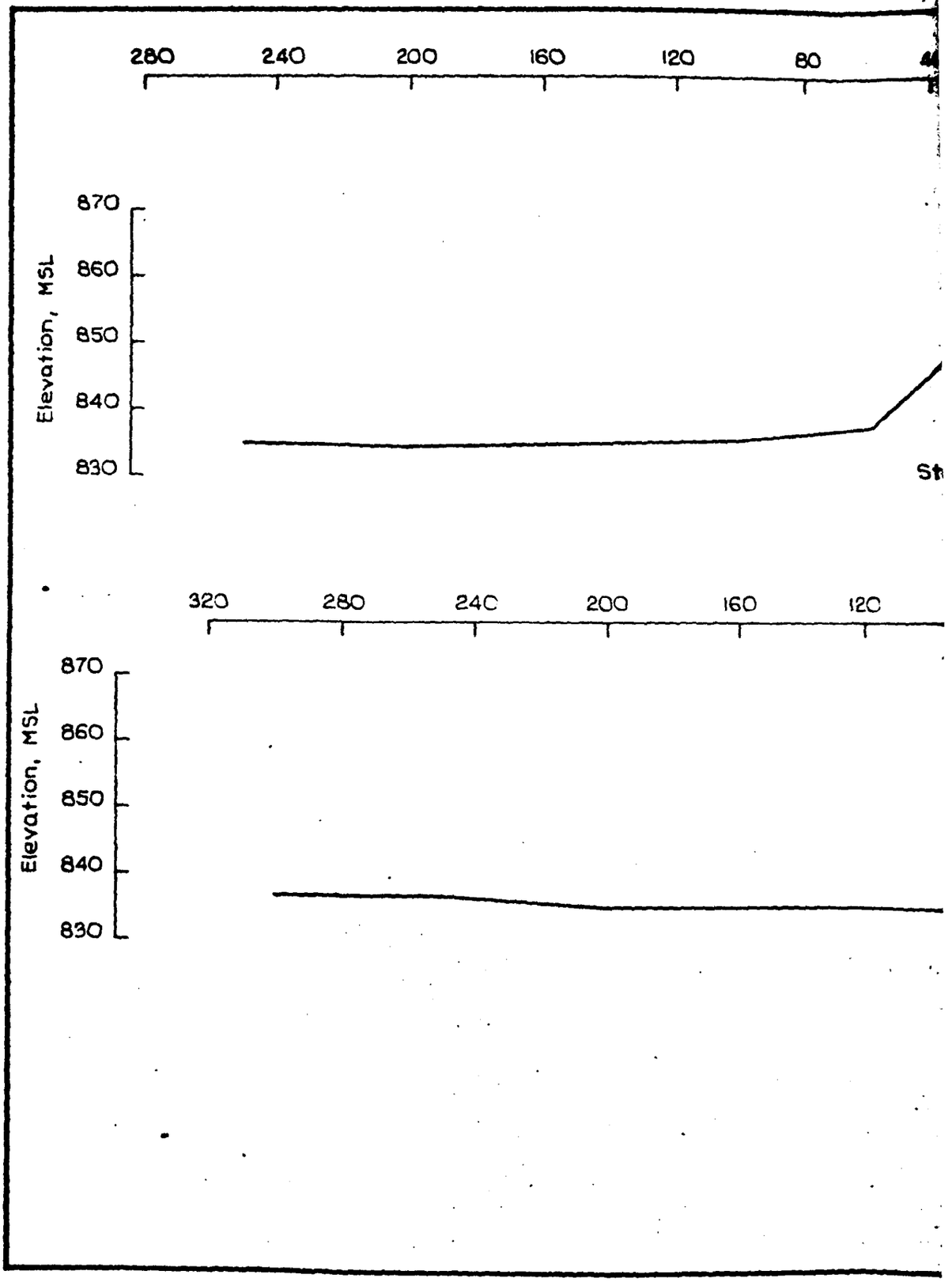
MO 31080

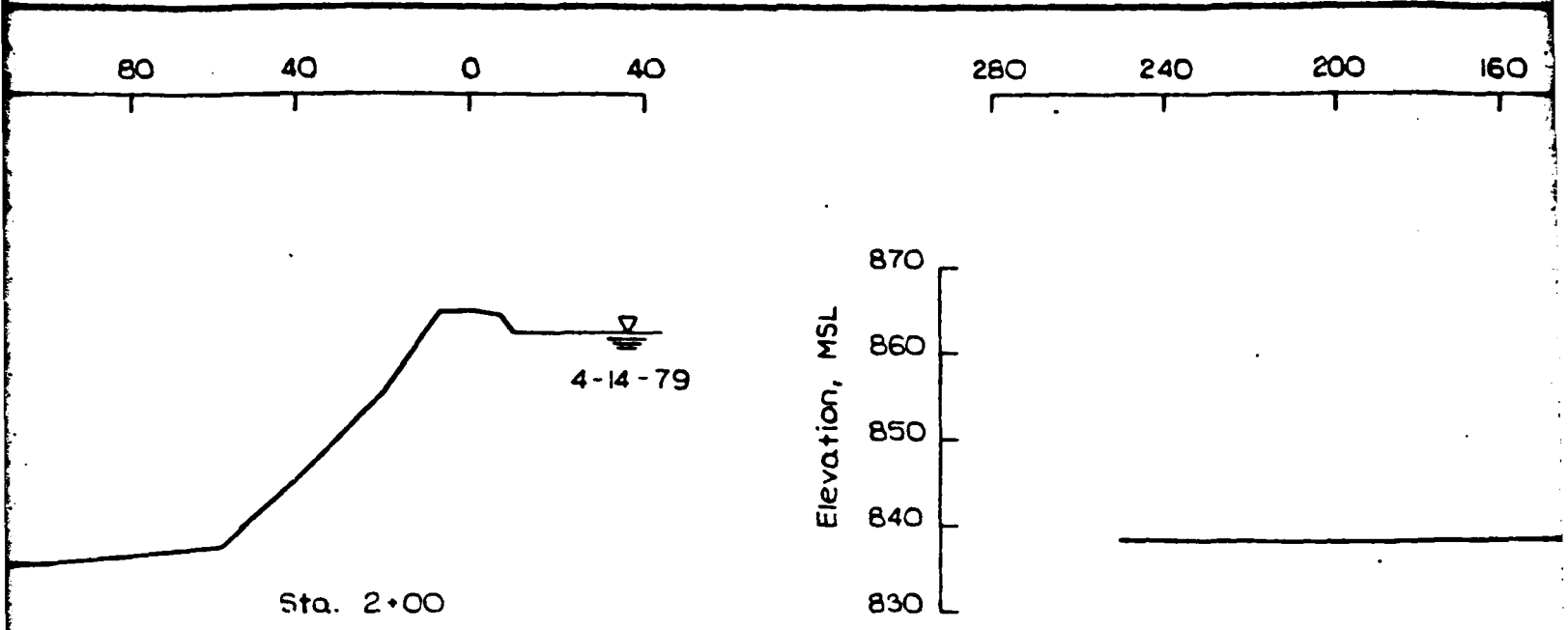
PRINCIPAL SPILLWAY PROFILES

DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT, CORPS OF ENGINEERS
TO ACCOMPANY DESIGN MEMORANDUM NO
DATE SERIAL FILE

5

PLATE 5


280
240
200
160
120
80
870
860
850
840
830
Elevation, MSL
320
280
240
200
160
120
870
860
850
840
830
Elevation, MSL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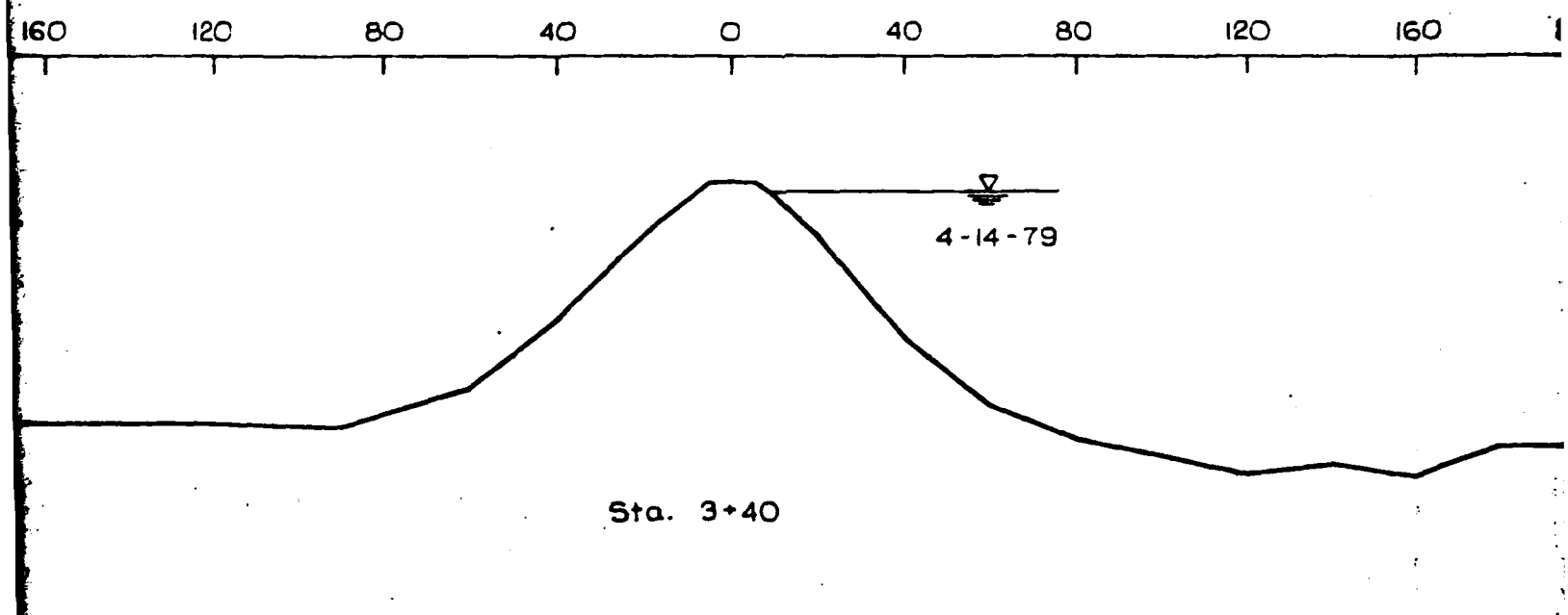
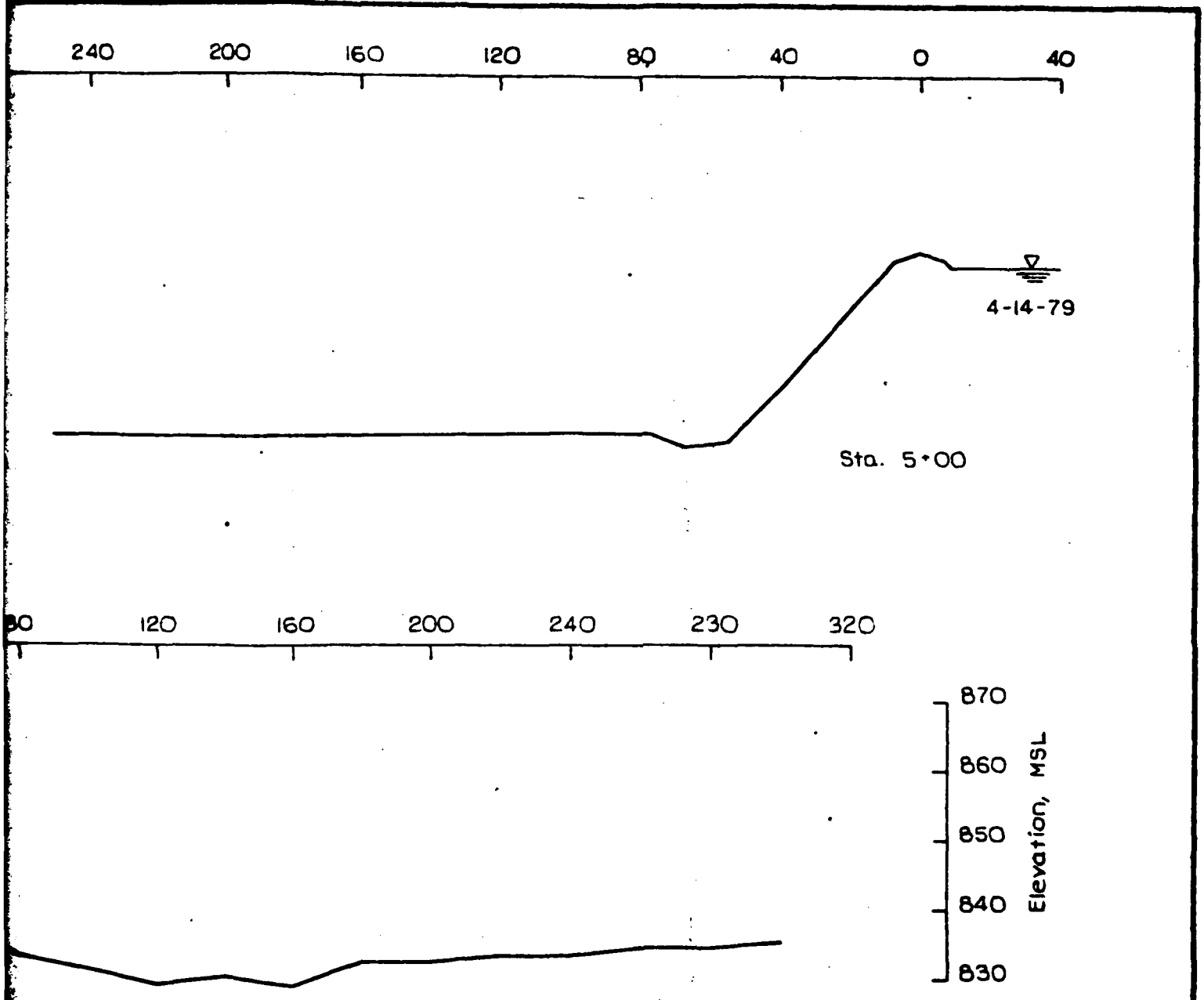
40
0
40
280
240
200
160
870
860
850
840
830
Elevation, MSL
4-14-79
Sta. 2+00


160
120
80
40
0
40
80
120
160
4-14-79
Sta. 3+40



ALL ELEVATIONS ARE FEET ABOVE MEAN SEA LEVEL

MISSISSIPPI RIVER AND TRIBUTARIES

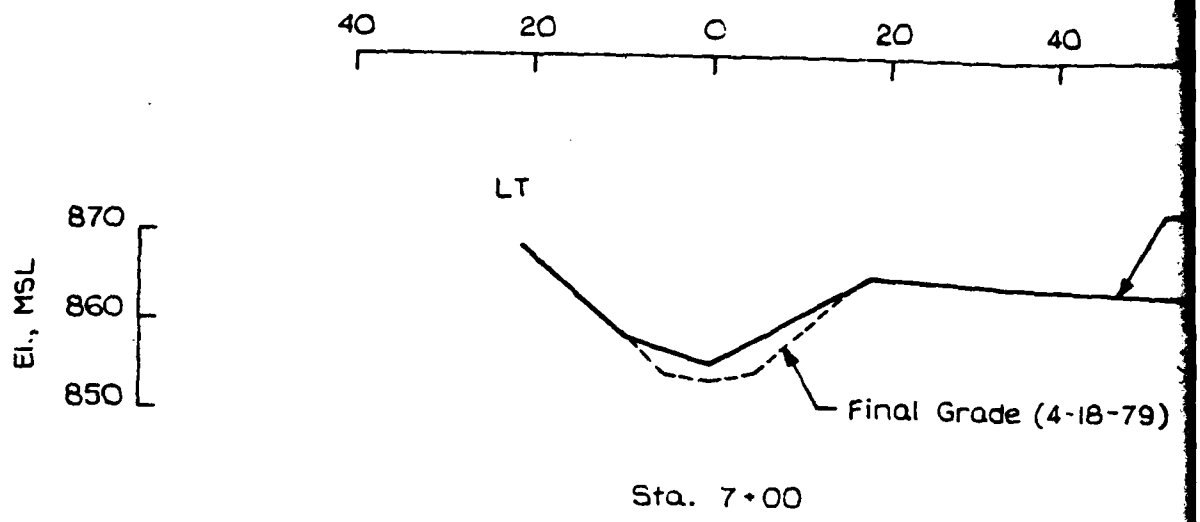
MO 31080

EMBANKMENT

CROSS-SECTIONS

DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT, CORPS OF ENGINEERS
TO ACCOMPANY DESIGN MEMORANDUM NO.
DATE. SERIAL. FILE.

PLATE 6



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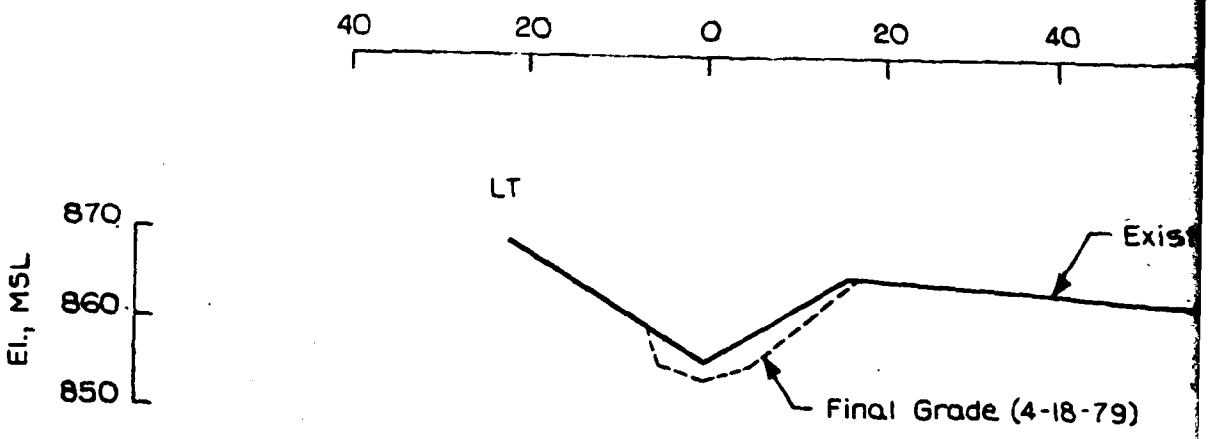

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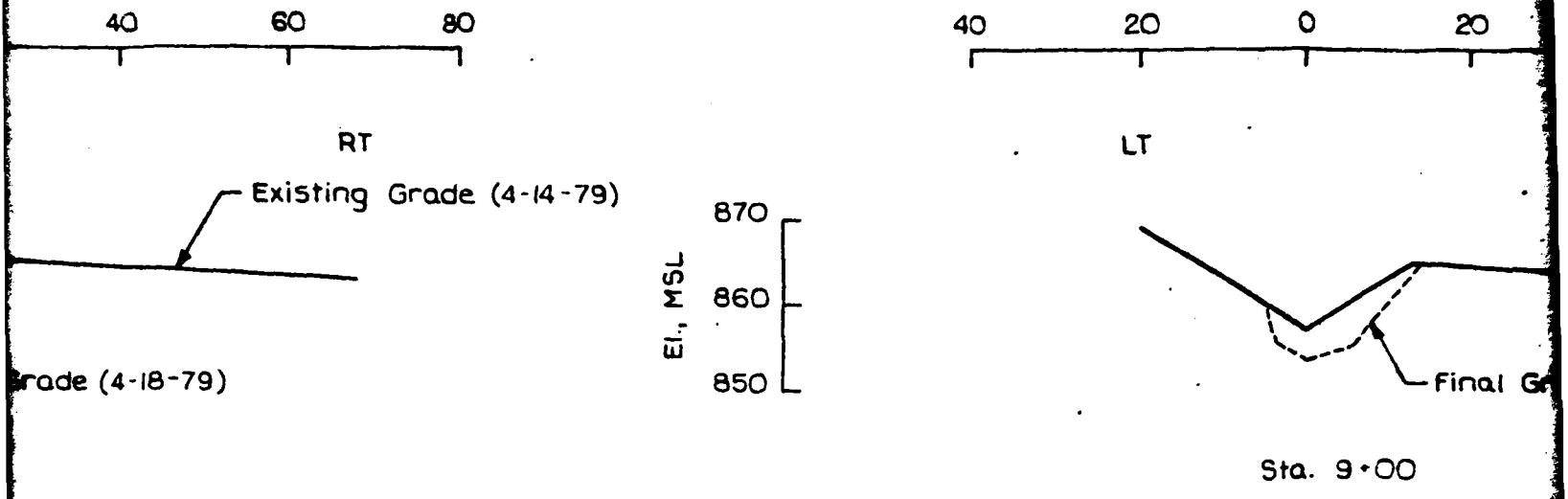
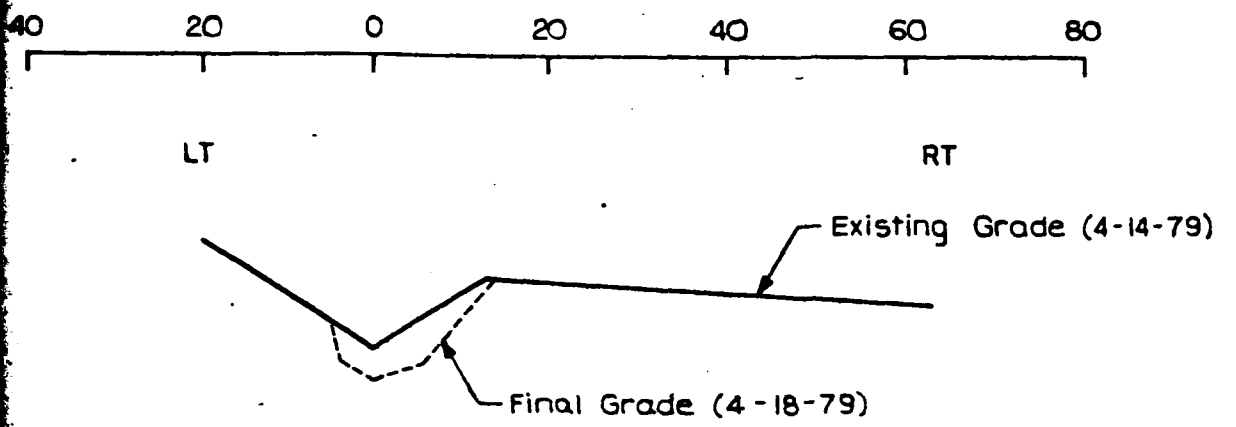


Sta. 9+00

Sta. 10+00



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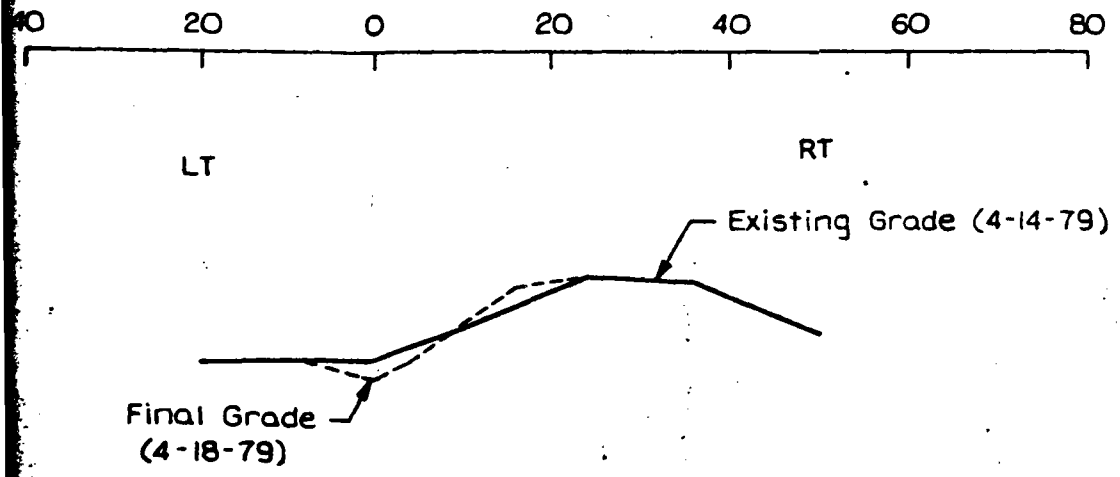


Sta. 10+00

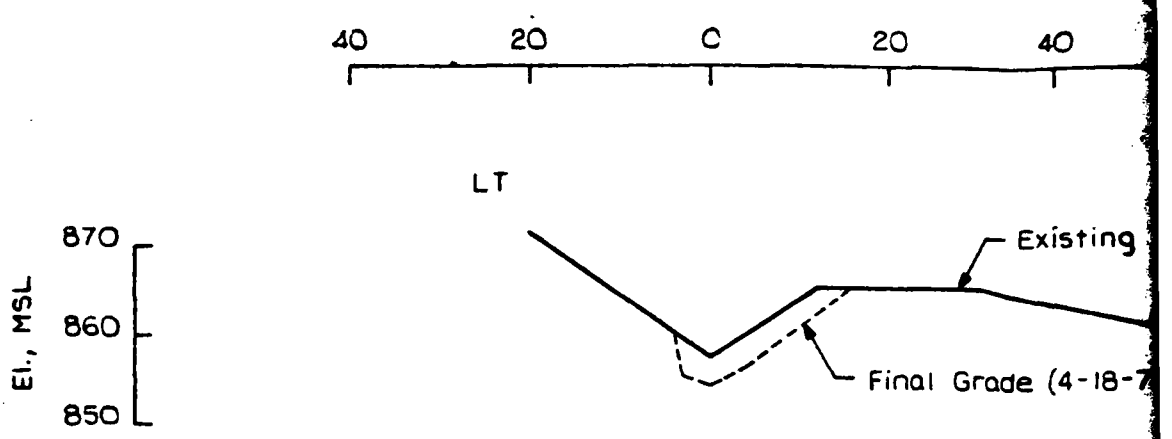
ALL ELEVATIONS ARE FEET ABOVE MEAN SEA LEVEL

MISSISSIPPI RIVER AND TRIBUTARIES

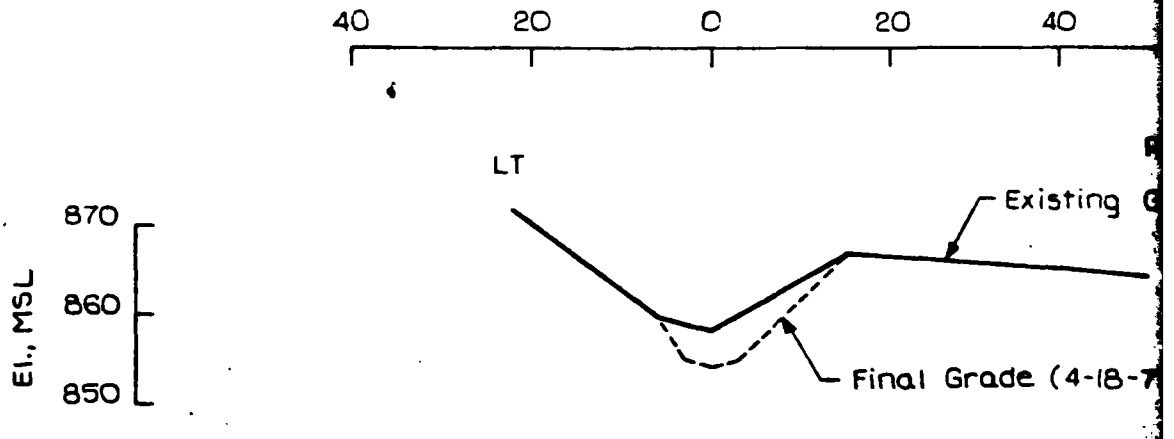
MO 31080

PRINCIPAL SPILLWAY CROSS-SECTIONS

DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT, CORPS OF ENGINEERS
TO ACCOMPANY DESIGN MEMORANDUM NO.
DATE. SERIAL. FILE.



Sta. 11+00



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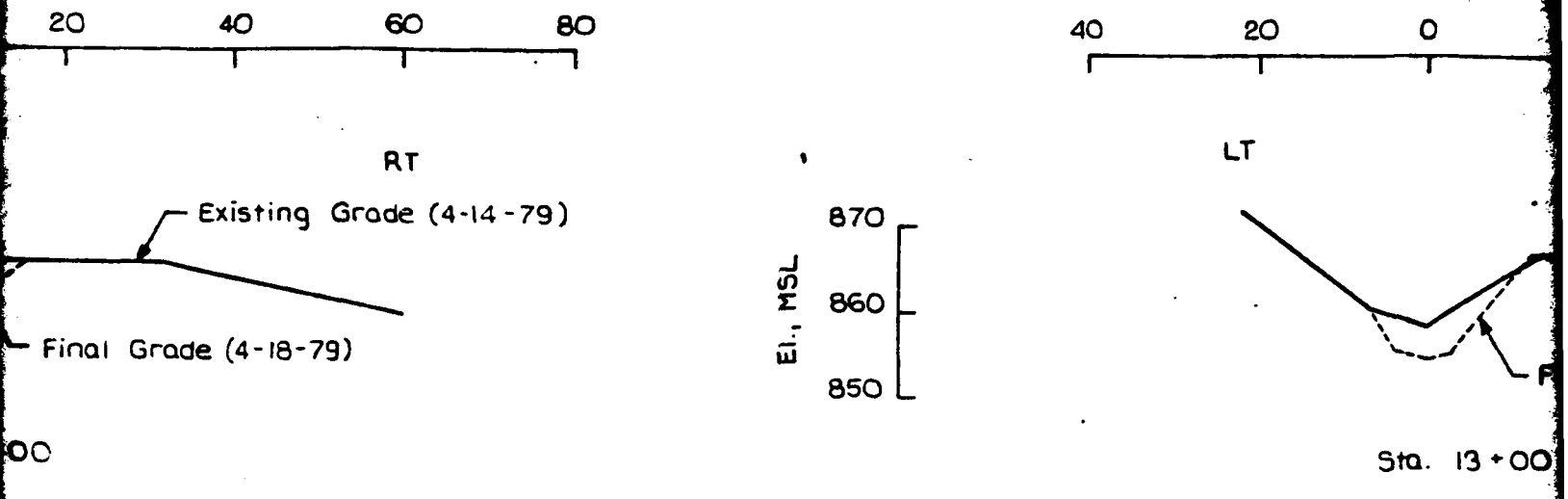
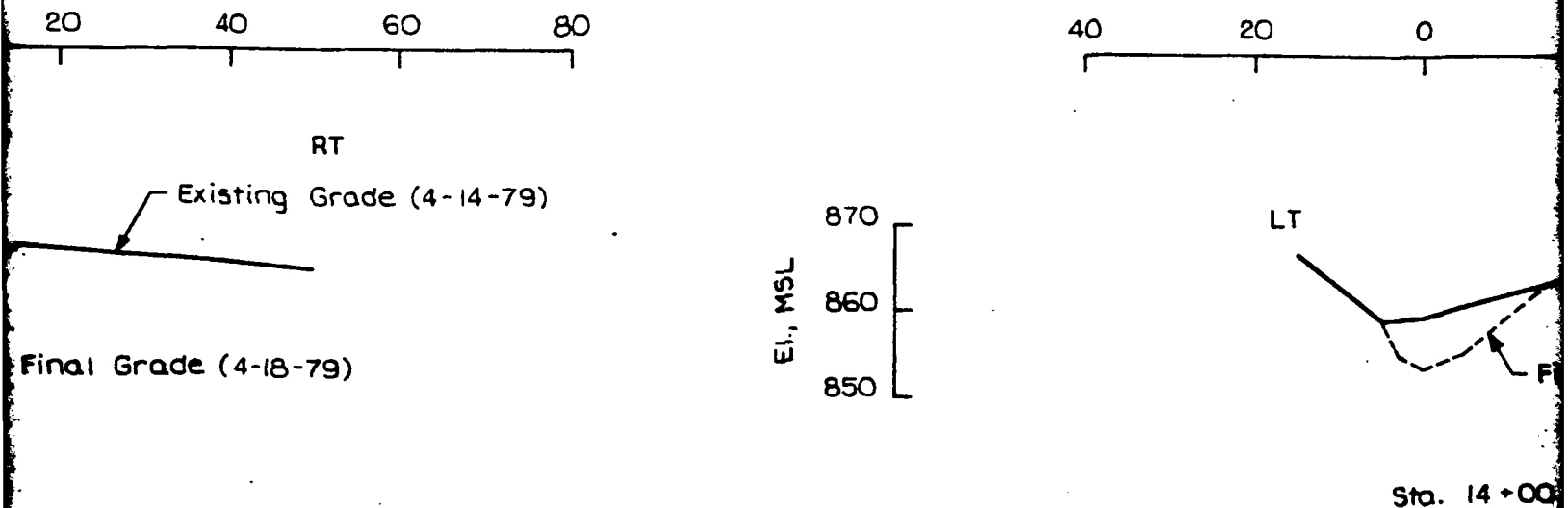

20
40
60
80
RT
Existing Grade (4-14-79)
Final Grade (4-18-79)
00
El., MSL
870
860
850
40
20
0
LT
F
Sta. 13 + 00


20
40
60
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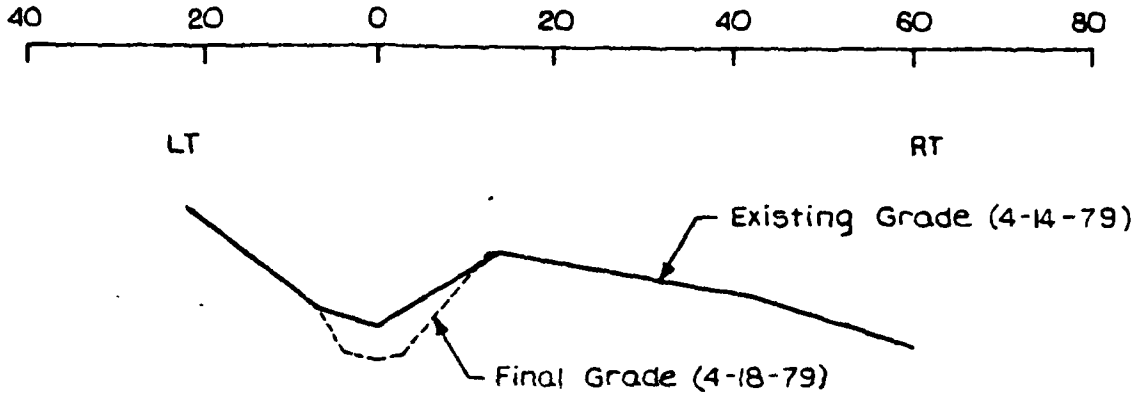
RT
Existing Grade (4-14-79)
Final Grade (4-18-79)
El., MSL
870
860
850
40
20
0
LT
F
Sta. 14 + 00



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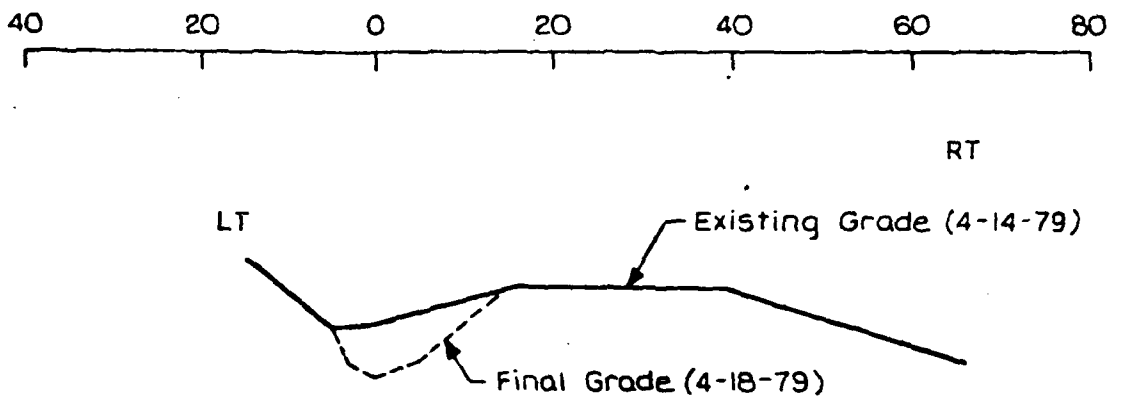


Sta. 14+00

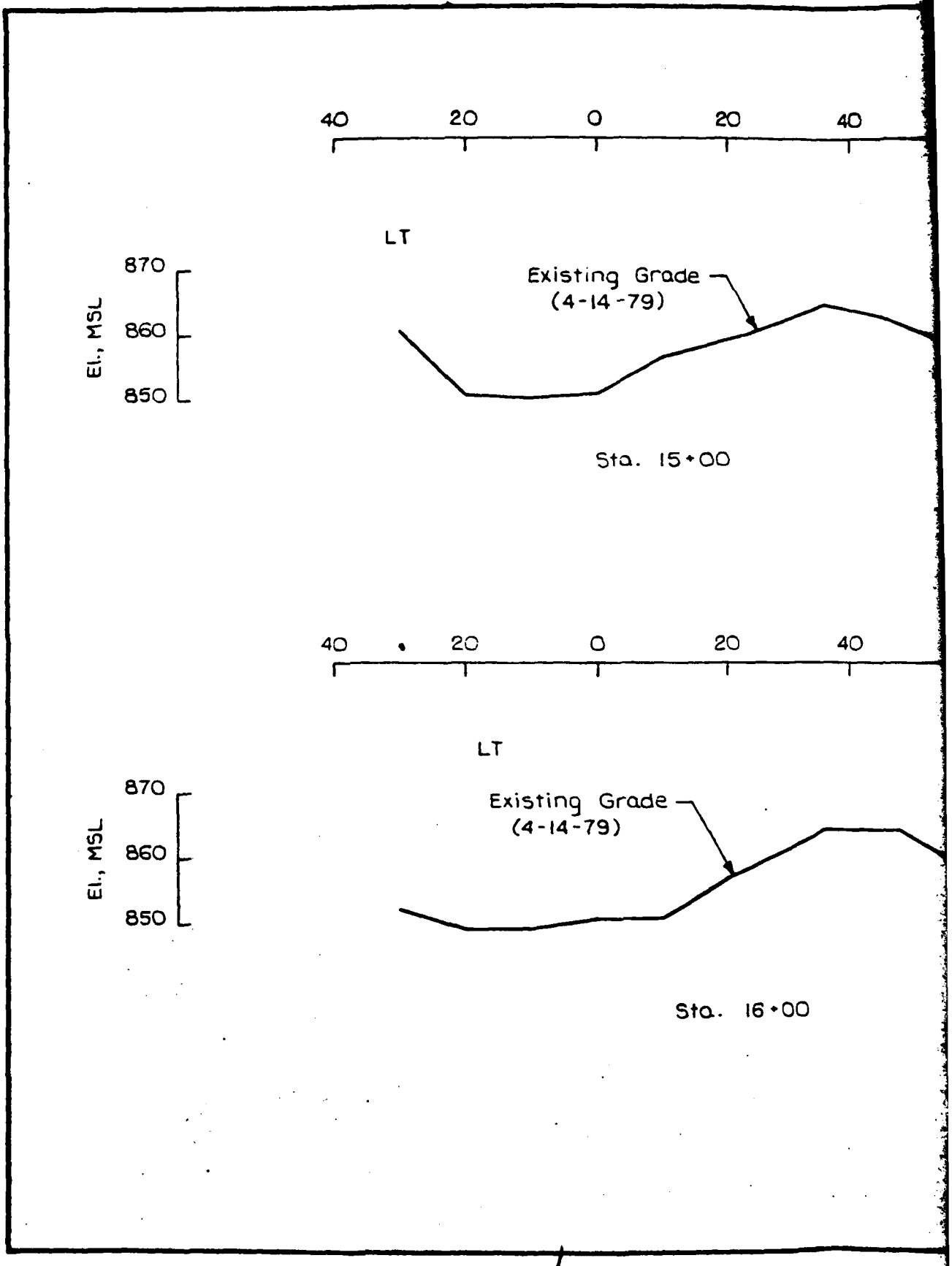
ALL ELEVATIONS ARE FEET ABOVE MEAN SEA LEVEL

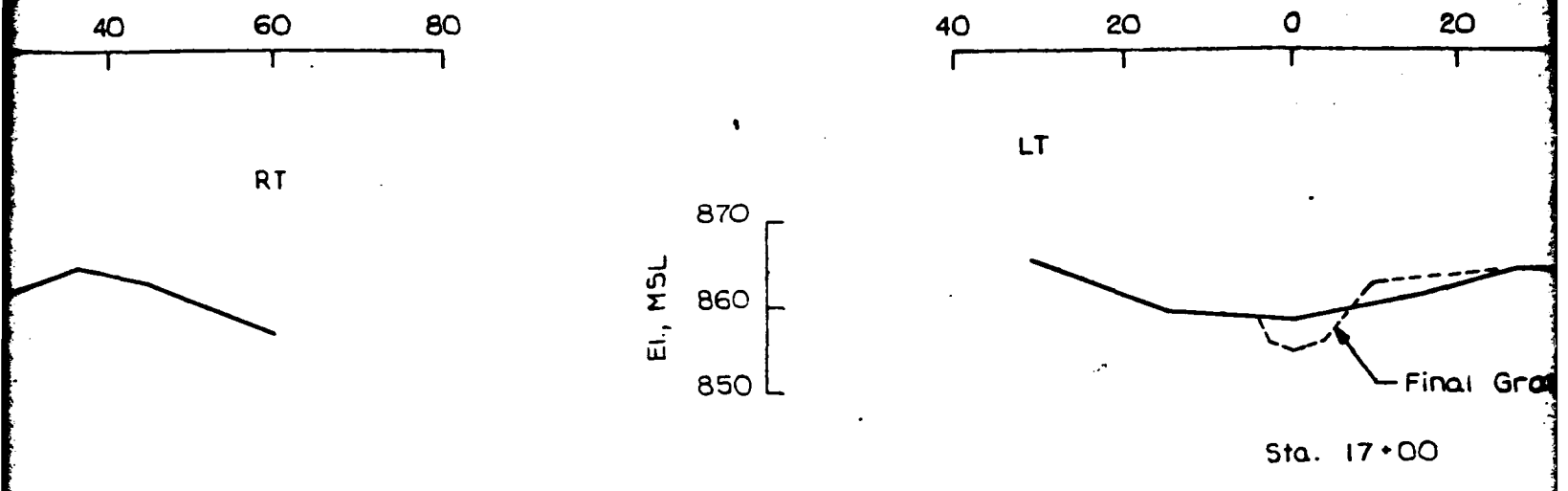
MISSISSIPPI RIVER AND TRIBUTARIES

MO 31080

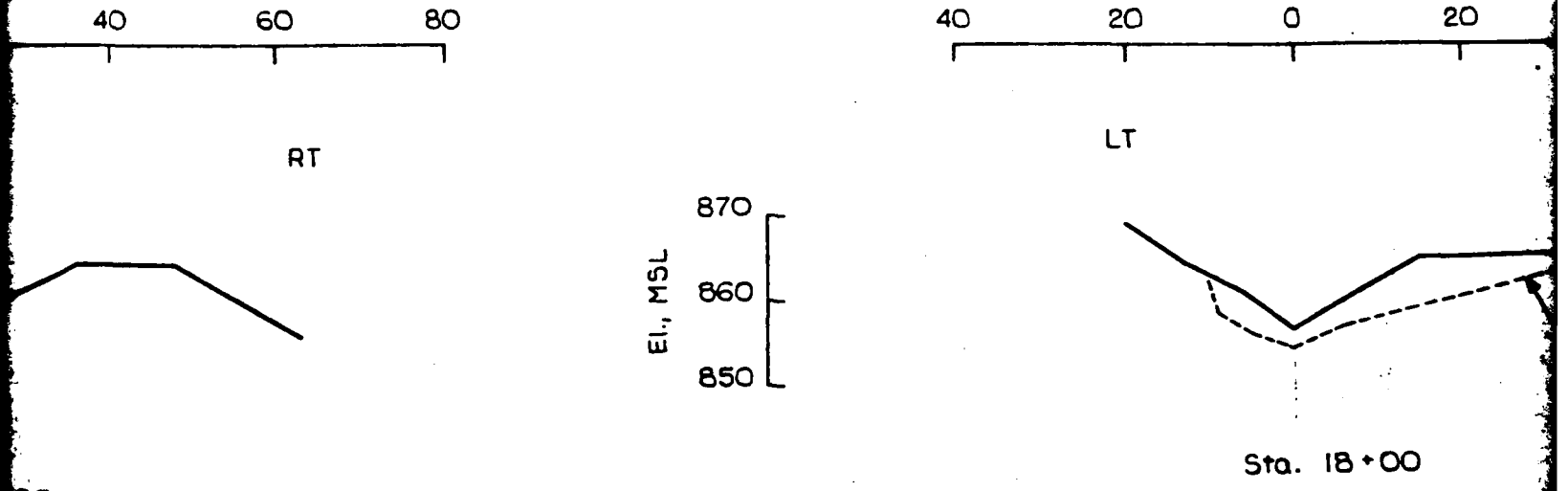
PRINCIPAL SPILLWAY CROSS-SECTIONS

DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT, CORPS OF ENGINEERS
TO ACCOMPANY DESIGN MEMORANDUM NO.
DATE. SERIAL. FILE.


40
20
0
20
40
LT
El., MSL
870
860
850
Existing Grade
(4-14-79)
Sta. 15+00
40
20
0
20
40
LT
El., MSL
870
860
850
Existing Grade
(4-14-79)
Sta. 16+00



Sta. 17+00



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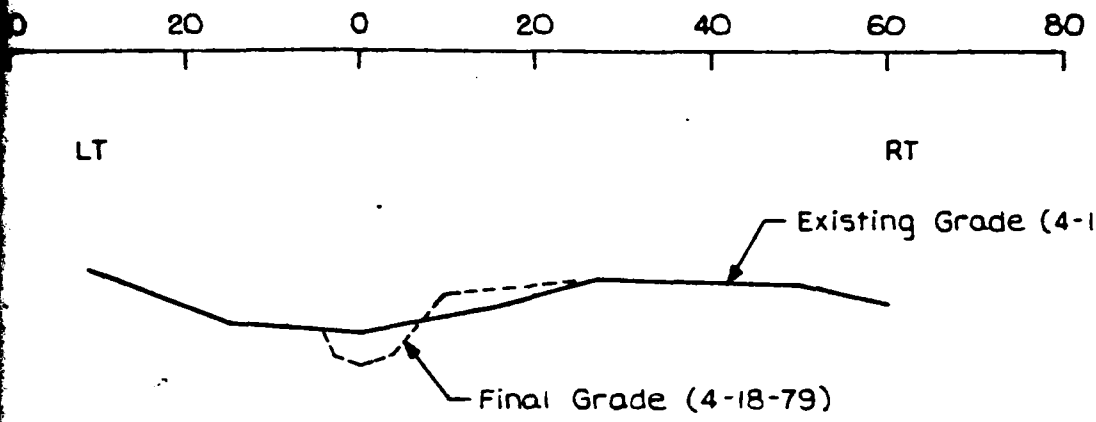
Sta. 18+00



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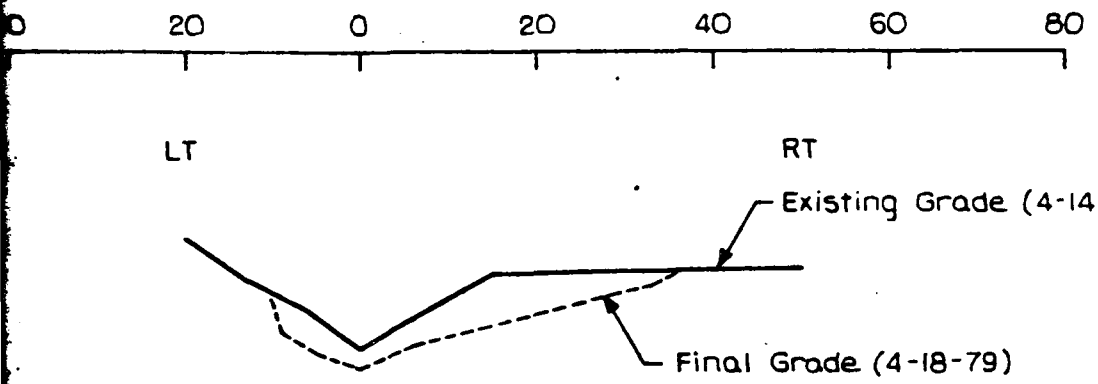


Sta. 18+00

ALL ELEVATIONS ARE FEET ABOVE MEAN SEA LEVEL

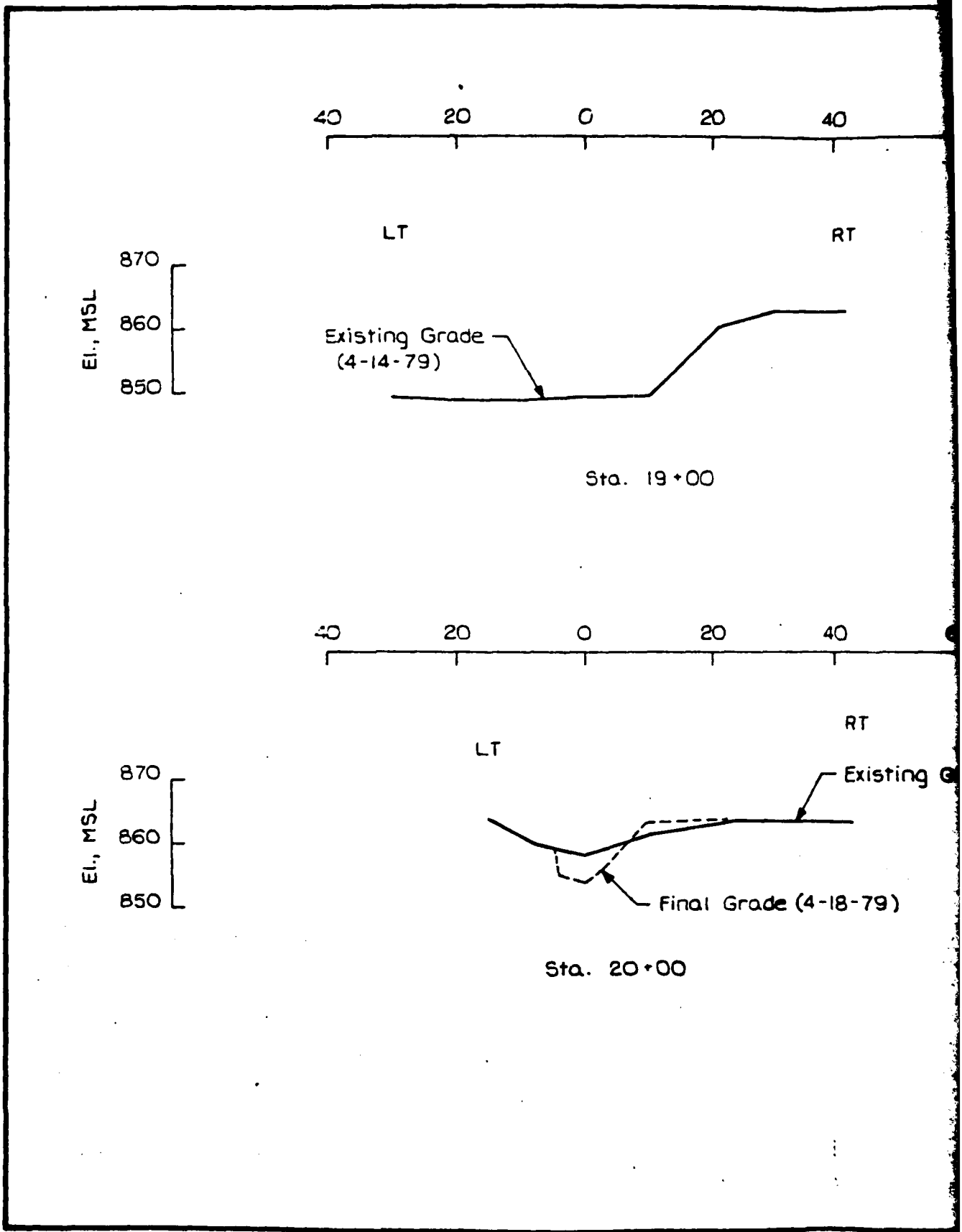
MISSISSIPPI RIVER AND TRIBUTARIES

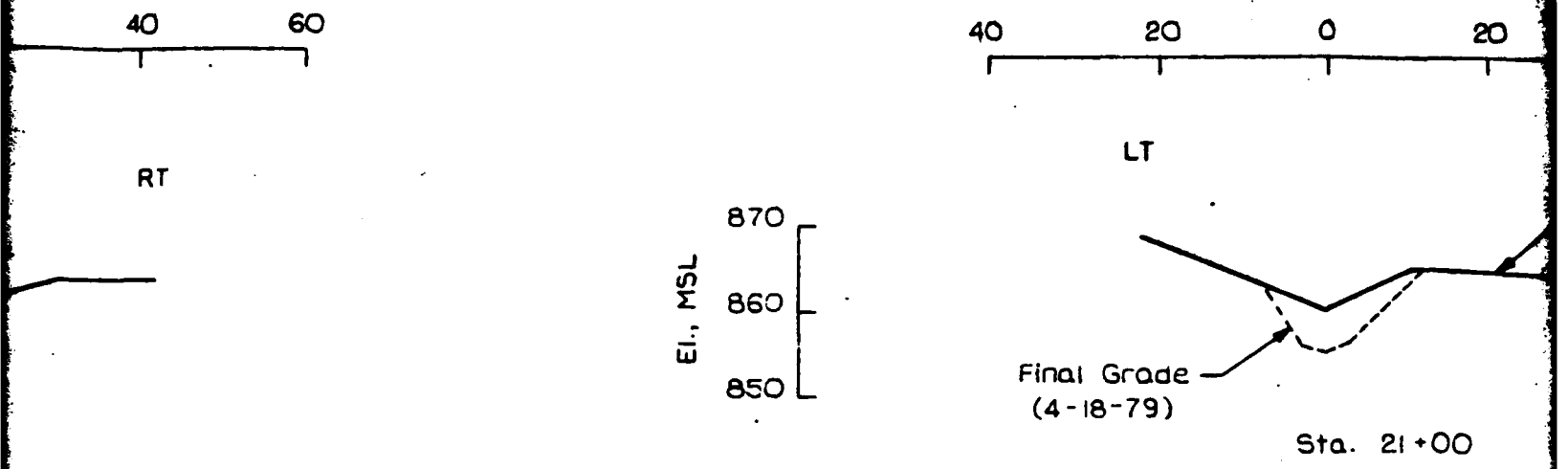
MO 31080

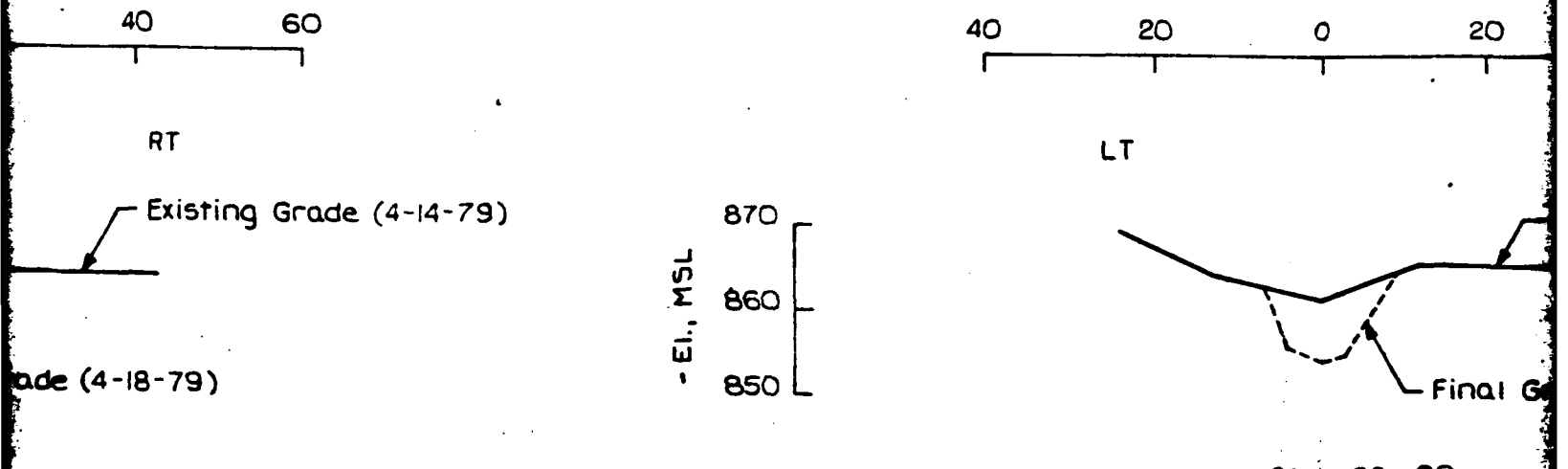
PRINCIPAL SPILLWAY CROSS-SECTIONS

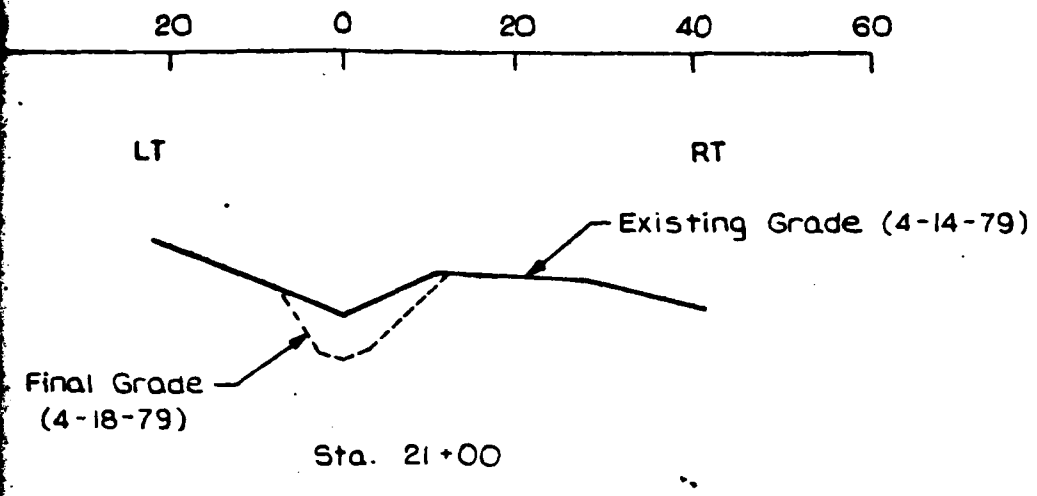
DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT, CORPS OF ENGINEERS
TO ACCOMPANY DESIGN MEMORANDUM NO.
DATE. SERIAL. FILE.

PLATE 7C


40
20
0
20
40
LT
RT
El., MSL
870
860
850
Existing Grade
(4-14-79)
Sta. 19+00
40
20
0
20
40
RT
LT
El., MSL
870
860
850
Existing G
Final Grade (4-18-79)
Sta. 20+00


40
60
RT
El., MSL
870
860
850
40
20
0
20
LT
Final Grade
(4-18-79)
Sta. 21+00


40
60
RT
Existing Grade (4-14-79)
ade (4-18-79)
El., MSL
870
860
850
40
20
0
20
LT
Final G
Sta. 22+00



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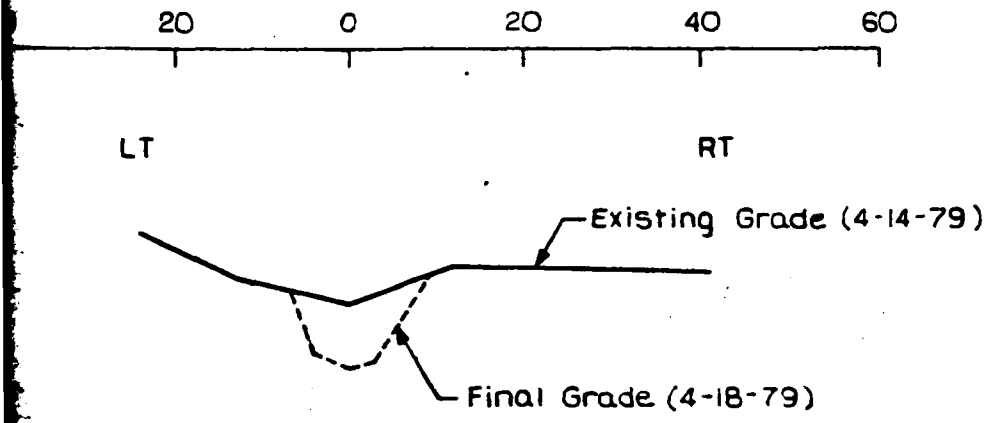


Sta. 22+00

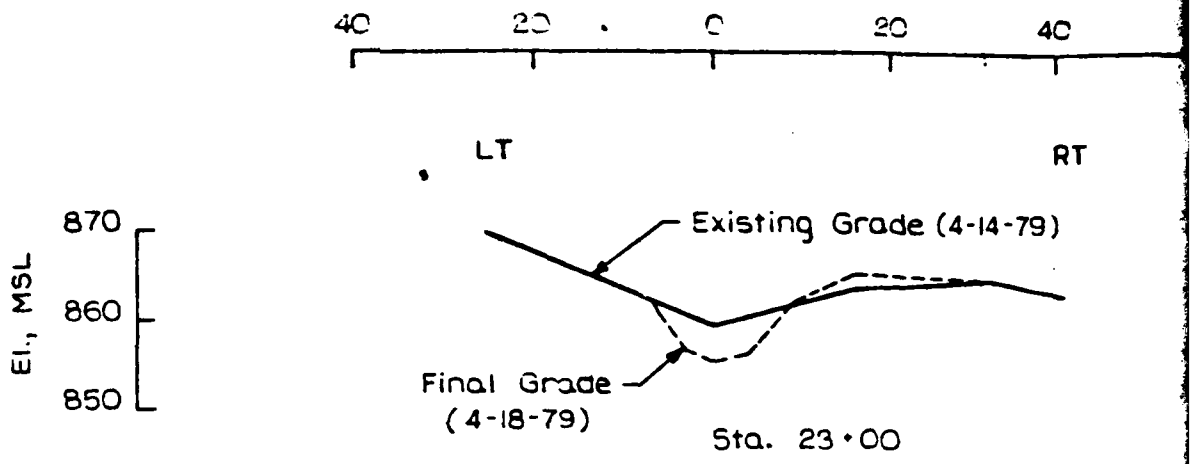
ALL ELEVATIONS ARE FEET ABOVE MEAN SEA LEVEL

MISSISSIPPI RIVER AND TRIBUTARIES
MO 31080

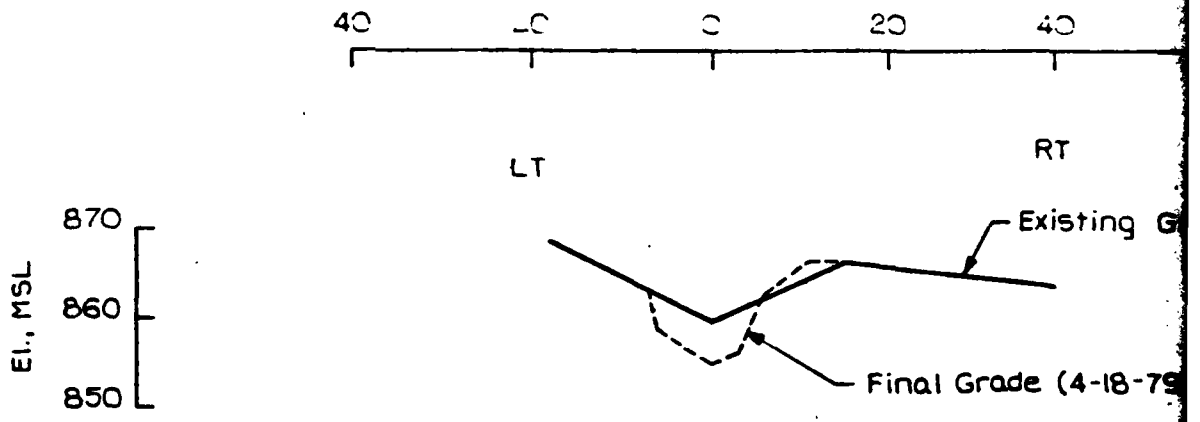
PRINCIPAL SPILLWAY
CROSS-SECTIONS

DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT, CORPS OF ENGINEERS
TO ACCOMPANY DECISION MEMORANDUM NO.
DATE. SERIAL. FILE.

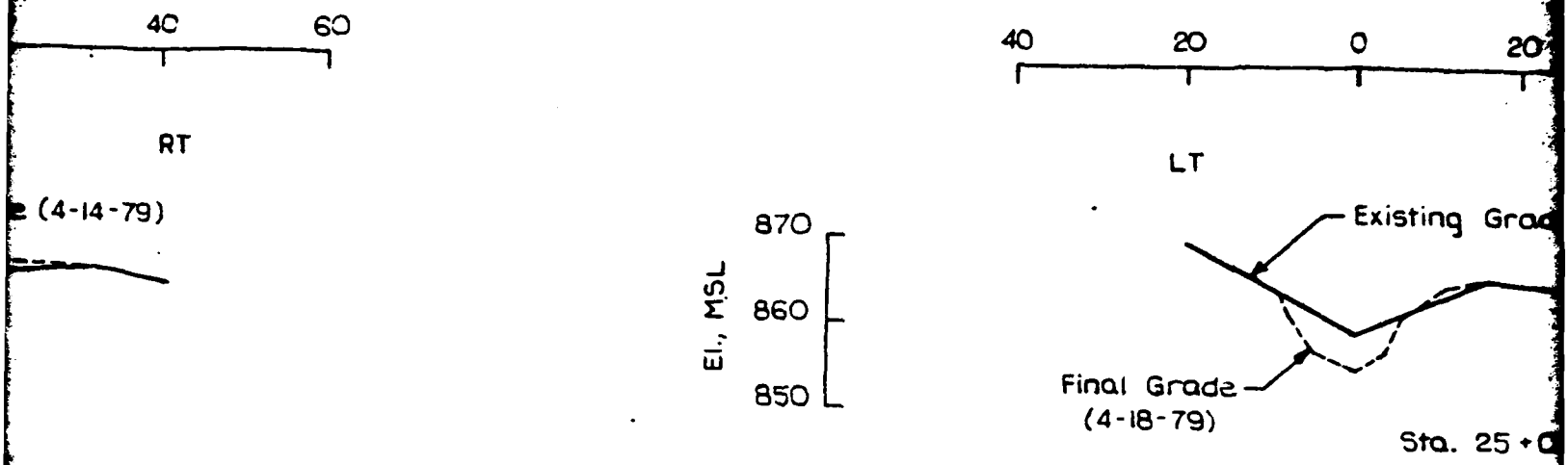
PLATE 7D

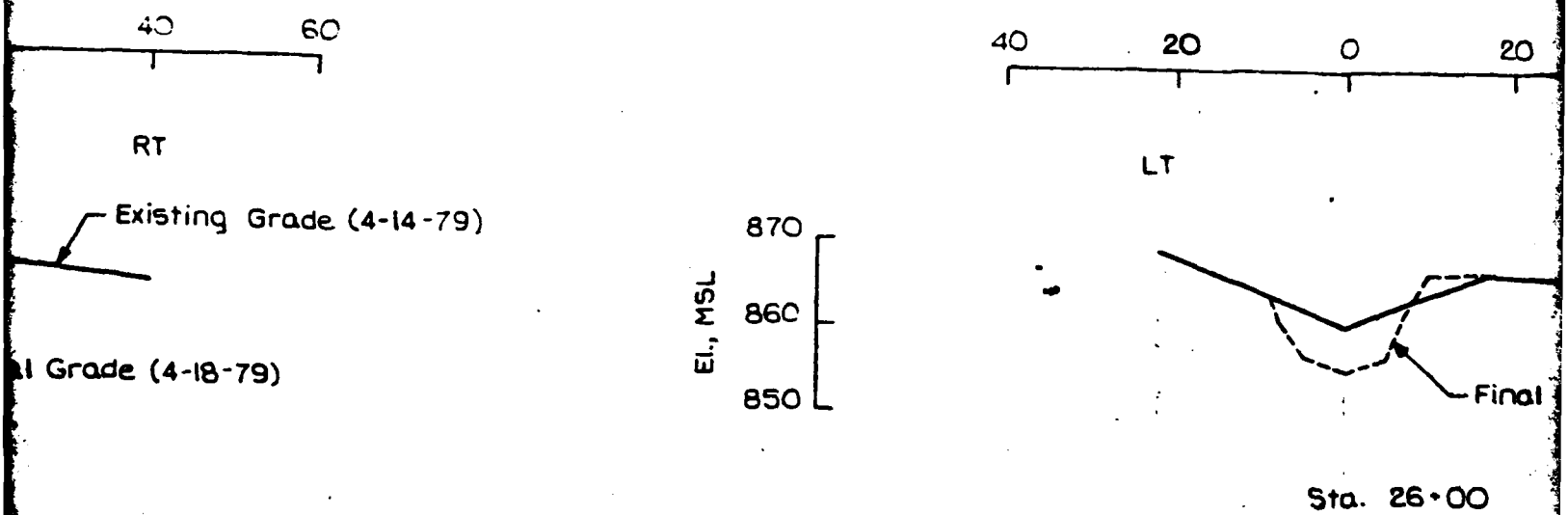


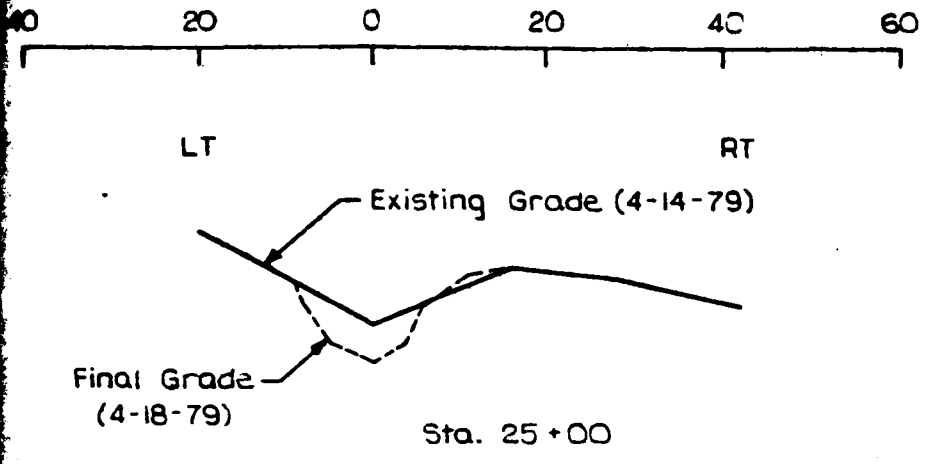
Sta. 23+00



Sta. 24+00


40
60
RT
(4-14-79)
870
860
850
El., MSL
40
20
0
20
LT
Existing Grad
Final Grade
(4-18-79)
Sta. 25+0


40
60
RT
Existing Grade (4-14-79)
l Grade (4-18-79)
870
860
850
El., MSL
40
20
0
20
LT
Final
Sta. 26+00



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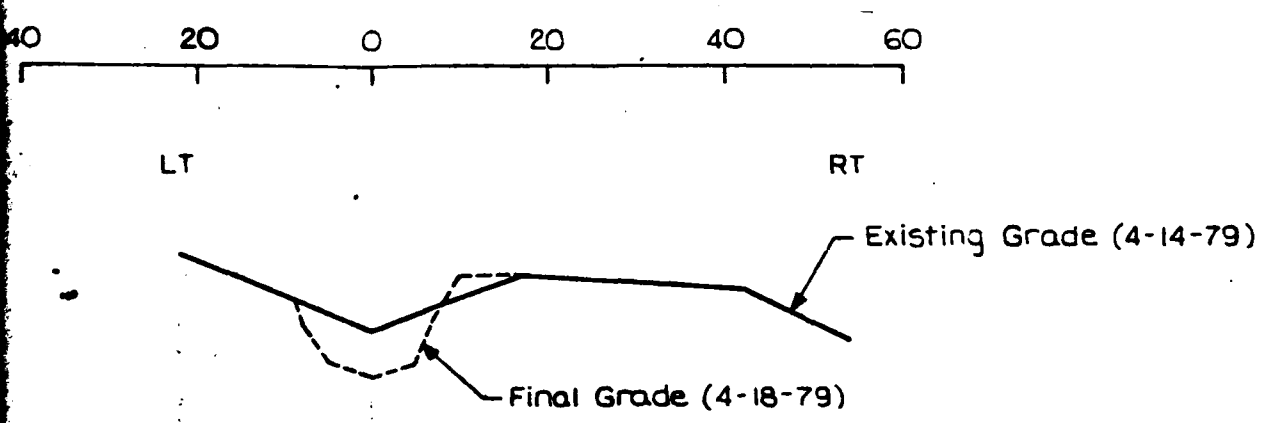


Sta. 26+00

ALL ELEVATIONS ARE FEET ABOVE MEAN SEA LEVEL

MISSISSIPPI RIVER AND TRIBUTARIES

MO 31080

PRINCIPAL SPILLWAY CROSS-SECTIONS

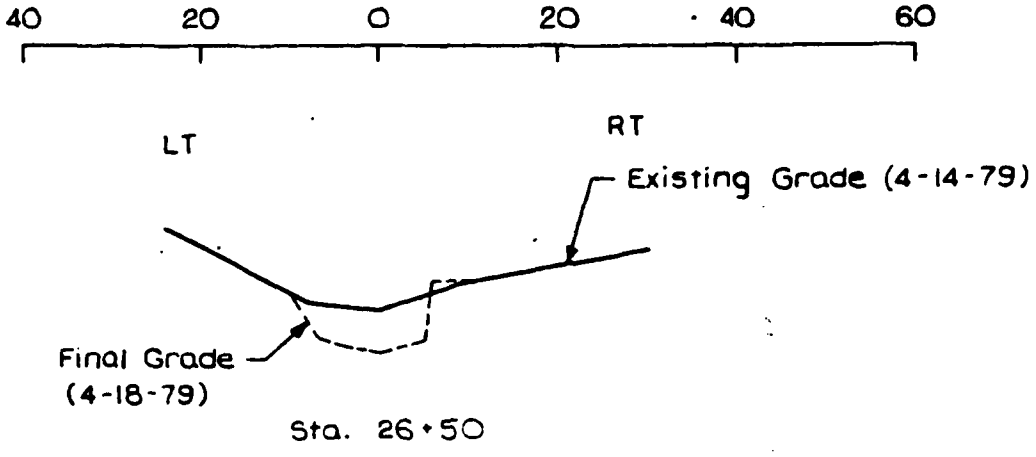
DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT, CORPS OF ENGINEERS
TO ACCOMPANY CESTON MEMORANDUM NO.
DATE. SERIAL. FILE.

EL., MSL
870
860
850

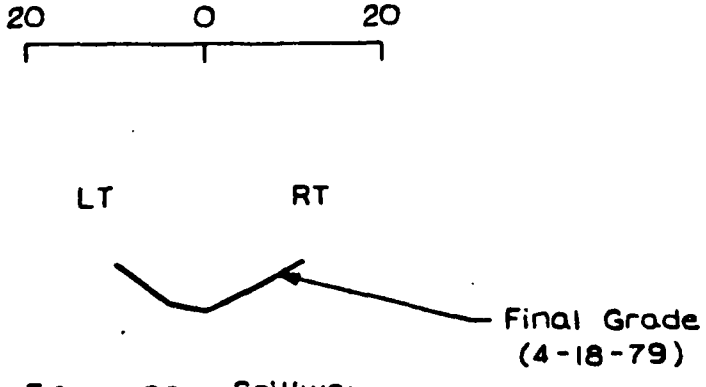
20

El., MSL
870
860
850

En



Sta. 26+50



Emergency Spillway
Section

60

Grade (4-14-79)

ALL ELEVATIONS ARE FEET ABOVE MEAN SEA LEVEL

MISSISSIPPI RIVER AND TRIBUTARIES

MO 31080

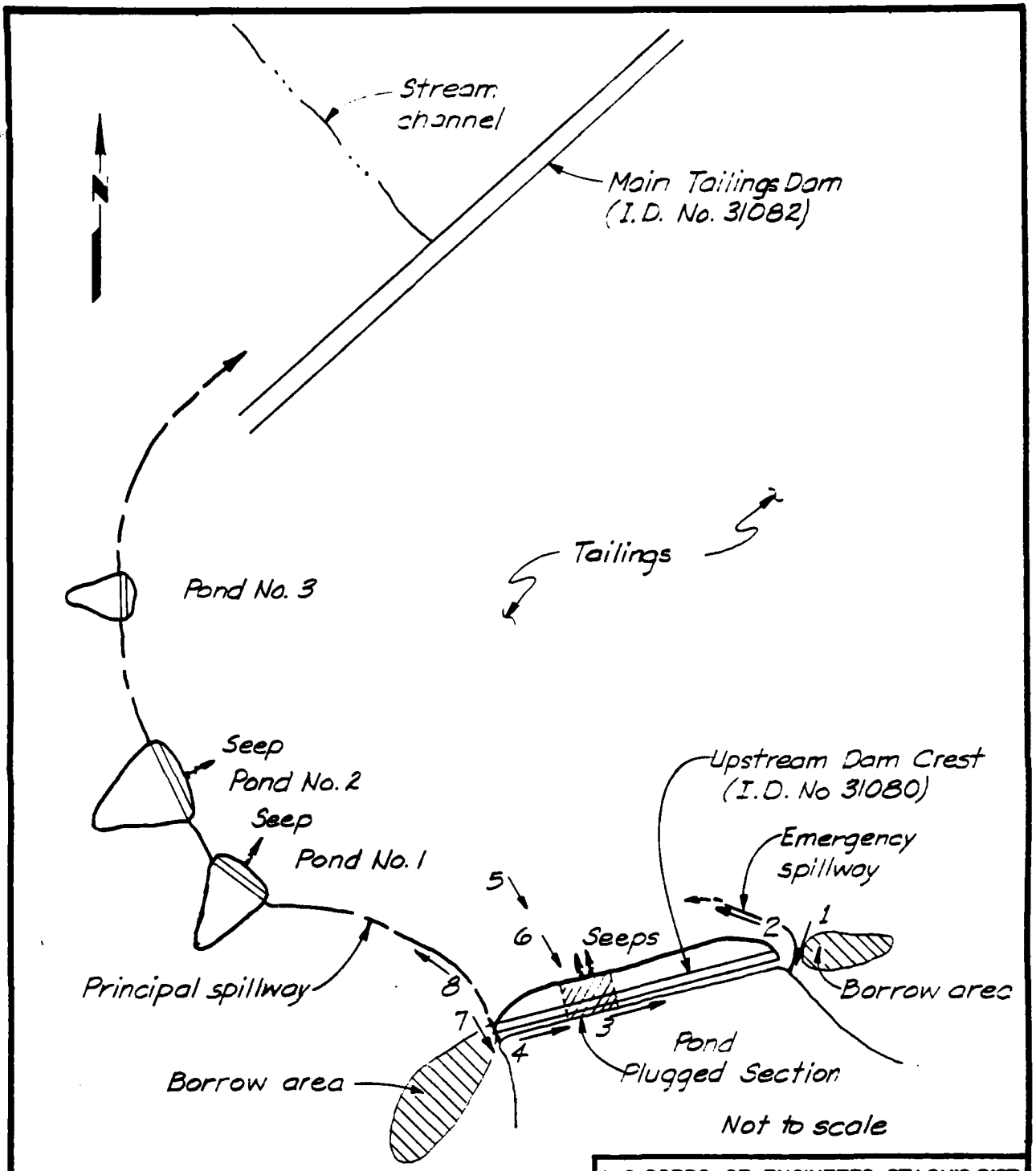
PRINCIPAL & EMERGENCY

SPILLWAY CROSS-SECTIONS

DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT, CORPS OF ENGINEERS
TO ACCOMPANY CESTON MEMORANDUM NO.
DATE. SERIAL. FILE.

PLATE 8

1 B



LEGEND:

4 → Photo number and view direction

U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

PHASE I INSPECTION OF DAMS
UPSTREAM DAM - I.D. 31080
PHOTOGRAPH LOCATION MAP

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET, SAN FRANCISCO, CALIFORNIA 94104

DESIGNED ____ INSPECTED MDF
DRAWN LSV RECOMMENDED ____
CHECKED ____ APPROVED RBK

DATE JUNE 2nd, 1979
DRAWING NO.
PLATE 9

PHOTOGRAPH RECORD

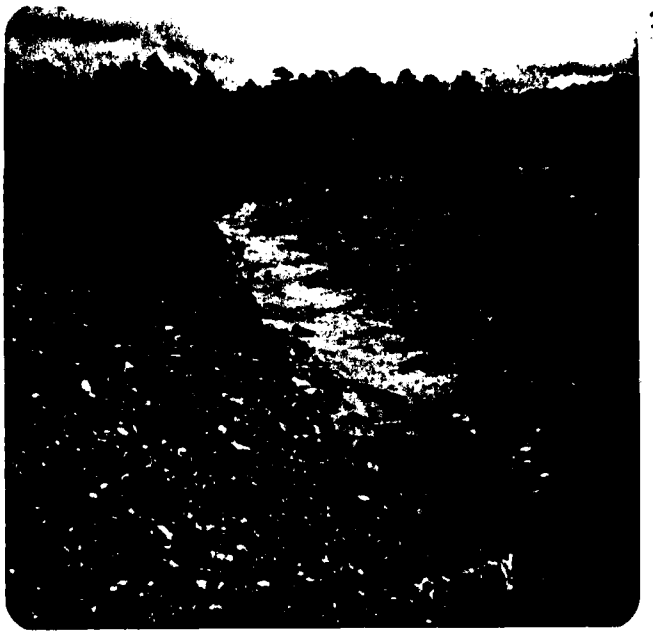
UPSTREAM DAM - I.D. NO. 31080

Photo No.	Description
1.	Upstream end of emergency spillway at right abutment.
2.	Downstream end of emergency spillway channel showing erosion.
3.	Upstream face of dam at the plugged section. Scarp has been formed by wave action; turbid water indicates active erosion is taking place.
4.	Upstream face of dam near left end.
5.	Downstream face of dam. The portion without vegetation is the section that was repaired in 1977 by constructing a plug in the breach.
6.	Downstream face of dam at the plugged section. Seepage at toe of dam and erosion rills on the face are shown. The dark zone on the face may be due to a high phreatic level.
7.	Upstream end of principal spillway at left abutment. The reservoir is in the background.
8.	View downstream in the principal spillway channel showing the overgrown condition. (Trees were removed by the Memphis District, Corps of Engineers, after the photograph was taken.)

NOTE: Photo Nos. 1, 2, 3, 4, 7 and 8 were taken on 29 March 1979.
Photo Nos. 5 and 6 were taken on 28 March 1979.

1

2


3


4

5

7

8


DA
FILM