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LEVEL II

LOWER DRESSER NO. 4 DAM
WASHINGTON COUNTY, MISSOURI
MO 31123

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
Serving the Army
Serving the Nation

St. Louis District

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

FOR: STATE OF MISSOURI

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

IN REPLY REFER TO

SUBJECT: Lower Dresser No. 4 Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Lower Dresser No. 4 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 of the dam and/or significant erosion of the spillway could result in failure of the dam.

3. Dam failure significantly increases the hazard to loss of life downstream.

4. Excessively steep downstream slope.

SUBMITTED BY: SIGNED
Chief, Engineering Division
25 SEP 1979
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer
25 SEP 1979
Date

LOWER DRESSER NO. 4 DAM
WASHINGTON COUNTY, MISSOURI

MISSOURI INVENTORY NO. 31123

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	Lower Dresser No. 4 Dam
State	Missouri
County	Washington
Stream	Tributary to Mill Creek
Date of Inspection	26 March 1979

Lower Dresser No. 4 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 Dresser Minerals Division of Potosi, Missouri. 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 impound water and tailings from a barite separation and beneficiation operation.

Lower Dresser No. 4 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 intermediate size. 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 about 2 miles downstream of the dam. Several dwellings, low-water bridges and railroad bridges are within this damage zone.

The results of the inspection and evaluation indicate that the spillway does not meet the criteria given in the Guidelines for a dam with the size and hazard potential of Lower Dresser No. 4 Dam. As an intermediate size dam with a high hazard potential, it is required by the Guidelines to pass the Probable Maximum Flood (PMF) without overtopping the crest. 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 spillway could pass a 100-year flood (a flood having a 1 percent chance of being equalled or exceeded in any 1 year) without overtopping the dam. It was also estimated that the spillway could pass 8 percent of the PMF without significant erosion of the spillway or embankment. However, the spillway cannot pass 50 percent of the PMF without overtopping the dam crest and without significant erosion of the spillway and embankment.

The spillway should be enlarged and/or the freeboard increased so that the PMF can be passed without overtopping the dam and without significant erosion of the embankment and spillway channel. Also, adequate erosion protection should be provided in the spillway.

The size of the downstream channel of the spillway should be enlarged and the channel extended a sufficient distance downstream of the dam to prevent flood discharges from eroding the embankment and/or the soils immediately downstream of the toe of the embankment. Adequate slope protection should be provided to prevent wave action from eroding the upstream face of the 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 tailings dams and should be made a matter of record.

The trees should be removed from the dam to prevent a potential seepage problem. They should be cleared under the guidance of an engineer experienced in the design and construction of earth dams.

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 spillway.

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 LOWER DRESSER NO. 4 DAM
FROM RIGHT ABUTMENT

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
LOWER DRESSSER NO. 4 DAM
ID NO. 31123

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
LOWER DRESSER NO. 4 DAM - ID NO. 31123

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 Lower Dresser No. 4 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) Lower Dresser No. 4 Dam is an earthfill dam that is used to impound water and tailings from a barite separation and beneficiation operation. The tailings consist of red-brown soft, silty clay and were deposited as a slurry in a water environment.

(2) The spillway is an open channel located at the right abutment. It is a broad V-shape at the dam axis and is in operable condition. No other outlets or regulating structures were found.

b. Location. The dam is located in the eastern portion of Washington County, Missouri, as shown in Plate 1. The dam (shown in Plate 2) is located in Section 14, Township 38 North, Range 3 East.

c. Size Classification. This dam is 40 feet high and is therefore in the intermediate 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 about 2 miles downstream of the dam. Several dwellings, low-water bridges and Missouri-Pacific Railroad bridges are within this damage zone.

e. Ownership. This dam is owned by:

Dresser Minerals Division
Dresser Industries, Inc.
P.O. Box 8
Potosi, MO 63664

f. Purpose of Dam. The purposes of the dam are to impound tailings from a barite separation and beneficiation operation and to collect surface runoff.

g. Design and Construction History. According to Mr. A. E. Williams, a representative of Dresser Minerals Division, the first stage of construction was completed in about 1957. A second stage was added in 1975 after failure of Dresser No. 4 Dam (I.D. 30474), which is located immediately upstream of Lower Dresser No. 4 Dam. The additional storage capacity was needed to contain muddy water released by Dresser No. 4 Dam when it failed.

h. Normal Operating Procedures. No operating records are known to exist. Dresser personnel consider the tailings impoundment inactive because tailings are no longer conveyed to the pond; however, the impoundment does retain tailings and collect runoff.

1.3 PERTINENT DATA

Field surveys were made by Booker Associates, Inc. of St. Louis Missouri on 28 March 1979. The survey data are shown in Plates 3, 4, and 5.

Drainage Area. 600 acres (Topographic Quadrangle, 7.5-minute series, Tiff, Missouri, 1937).

b. Discharge at Damsite.

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

(2) Spillway discharge for pool at top of dam (El. 737.5) - 680 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. 737.5 to El. 740.5.

(2) Spillway crest - El. 733.4.

(3) Streambed at downstream toe of dam - El. 702 ±.

(4) Water surface on 28 March 1979 (date of survey) - El. 730.4.

d. Reservoir. Length of impoundment - (from aerial photograph, scale: 1 inch = 1000 feet).

(1) For pool at spillway crest (El. 733.4) - 1000 feet ±.

(2) For pool at top of dam (El. 737.5) - 1500 feet ±.

e. Storage.

(1) Spillway crest (El. 733.4) - 103 acre-feet.

(2) Top of dam (El. 737.5) - 133 acre-feet.

f. Reservoir Surface Area.

(1) Spillway crest (El. 733.4) - 7.4 acres.

(2) Top of dam (El. 737.5) - 8.8 acres.

g. Dam.

(1) Type - Earthfill.

(2) Length - 311 feet.

(3) Height (maximum above streambed) - 40 feet.

(4) Top width - Varies from about 35 to 70 feet.

(5) Side slopes -

(a) Downstream: 1.5(H) to 1.0 (V).
(b) Upstream: 1.5(H) to 1.0(V) above water surface.

1/ Elevations are based on a reference datum of 743.00 M.S.L. at the temporary bench mark (see Plate 3). This elevation was estimated from the topographic quadrangle.

(6) Zoning - It is not known if a starter dam was constructed. The shell consists of sands and angular gravels generally finer than 7/8-inch.

(7) Cutoff - During an interview, the Dresser representative stated that a cutoff could have been constructed although this could not be confirmed.

h. Spillway.

(1) Type - uncontrolled open channel spillway at the right abutment.

(2) Control section - broad V-shape, 4.3-foot depth and 58-foot top width.

(3) Crest elevation - El. 733.4 M.S.L.

(4) Upstream channel - wide swale and cleared of vegetation.

(5) Downstream channel - 3 to 4 feet deep, 5 to 6 feet wide, U-shaped channel in bedrock.

i. Regulating Outlets. None.

j. Diversion Ditches. Two diversion ditches conduct water to the impoundment formed by this dam. A diversion ditch conducts water from the mill site to the upper end of the impoundment. Another diversion ditch carries water from the north end of Dresser No. 4 Dam (I.D. 30474) around the west side of that dam to the upper end of the Lower Dresser No. 4 impoundment. This diversion ditch is U-shaped and about 8 to 10 feet deep. A cross-section of this ditch is shown in Plate 5A in Appendix B.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No design drawings or data are known to exist.

2.2 CONSTRUCTION

Mr. A. E. Williams, the owner's representative, indicated that the dam construction began in about 1957. He stated that a core trench may have been built prior to construction of the dam, but no drawings or records exist to confirm this. He also said that a starter dam may not have been constructed. Gravels were hauled to the site and dumped to build the dam. In 1975, the dam was raised to accommodate an increased volume of runoff from the impoundment of Dresser No. 4 Dam (I.D. No. 30474) that had failed. Gravels were hauled to the dam to raise the structure and broaden its crest. The Dresser Minerals representative did not estimate how much the dam was raised during the second stage construction.

2.3 OPERATION

No records of operation are known to exist. The outflow of surface runoff would pass through an uncontrolled spillway.

2.4 EVALUATION

a. Availability. No design or construction records were available. The only information made available to the inspection team was provided during conversations with the owner's representative.

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 should be made a matter of record.

c. Validity. Not applicable because no design data were available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. Mr. A. E. Williams of Dresser Minerals met with the inspection team on 21 March 1979 and again, briefly, on 26 March 1979. The dam was inspected by a civil engineer and engineering geologist from International Engineering Company, Inc. on 26 March 1979. The impoundment contains barite mining tailings, and, although tailings are no longer conveyed to the site, the pond is a storage site for runoff. Water was standing in the pond at the time of the inspection, and the tailings were below the water surface. The Dresser representative indicated that the tailings slope down toward the west. The depth of water above the tailings could not be determined. Photographs taken during the inspection are included in this report. The field locations of the photographs are shown in Plate 6.

b. Project Geology. Bedrock in the reservoir area consists of dolomite with chert and druse of the Potosi Formation of Upper Cambrian Age. Outcrops are generally restricted to stream channels. Throughout most of the area, the bedrock is overlain by a red clay that contains remnants of chert, barite, and quartz druse. The red clay can be as much as 15 feet thick, but it averages less than 10 feet in thickness and is thinner on the hillsides. Bedrock is exposed in the spillway channel at the right abutment.

c. Dam. The plan of the dam is shown in Plate 3. The profile and cross-sections of the dam and spillway are shown in Plates 4 and 5.

Vegetation on the embankment is limited. A few scattered trees are growing on the downstream face of the dam, and there are small trees on the crest near the right abutment. The crest and slopes are mostly barren; but grass and briers are growing at the right abutment, and growth tends to be heavier at the ends of the dam.

No sliding, detrimental settlement, depressions, cracking, sinkholes or animal burrows were observed at the embankment. Wave erosion was observed at the water surface line on the upstream face; a 9-inch high scarp and beach were noted.

Two springs were observed at the maximum section of the dam at the downstream toe. The springs are approximately 15 feet apart and are shown on the plan of the dam, Plate 3. At the time of the inspection, the flow from Spring No. 1 was estimated to be 15 to 25 gpm. Spring No. 2 was flowing at an estimated rate of about 5 gpm. The ground was firm at both springs. The flow from both springs was clear and there was no evidence of piping. Some vegetation and trees are growing in the channels where the springs emerge from the dam.

The difference in elevation between the dam crest and the pond water surface varied from 7 to 10 feet on the date of the survey (28 March 1979). The elevation difference from the spillway crest to the low point on the dam crest is 4.1 feet.

There is no slope protection on the upstream face of the dam.

d. Appurtenant Structures. The spillway is an open channel located at the right abutment. The channel bottom is founded in or near the rock surface and is a wide V-shape at the dam axis and then narrows downstream of the dam. A thin mantle of gravelly clay covers the rock surface in the channel bottom at the dam. Clayey soil was observed overlying the bedrock in the side walls of the spillway. The extent and depth of this soil cover could not be determined during the inspection. Bedrock is exposed in the downstream channel, and its entire length has a rough stairstep profile. Downstream of the dam, the channel is approximately 5 to 6 feet wide, 3 to 4 feet deep and U-shaped. The downstream channel is about 200 feet long and curves slightly toward the toe of the dam. The approach to the spillway is a wide swale. There are no other outlets at the dam.

A diversion ditch upstream and to the west of Dresser No. 4 Dam (I.D. No. 30474) directs surface runoff into the pond. Another diversion ditch directs runoff from the mill site into the pond.

e. Reservoir Area. No evidence of landslides was observed along the shoreline of the pond. Minimal erosion was observed along the shoreline of the pond. The shoreline is covered with trees and a thick ground cover of leaves and low vegetation. Sedimentation from natural sources appears to be minor. The reservoir contains soft silty clay tailings and water.

There is a potential for backwater flooding. The pond water surface could reach the downstream toe of Dresser No. 4 Dam, which is located about 1500 feet upstream of Lower Dresser No. 4 Dam. The spillway crest of Lower Dresser No. 4 Dam is only about 1 to 2 feet lower than the toe of Dresser No. 4 Dam.

f. Downstream Channels. Two small, parallel streams join into one about 800 feet downstream of the dam. These flow in shallow channels that range in width from 1.5 to 4.0 feet. Water was flowing at a depth of 2 to 3 inches during the field inspection. The sources of the water were seepage or natural springs located at the toe of the dam. The channel bottoms are covered with small gravel, and the side slopes are heavily vegetated with hardwood trees and brush. The single channel empties into an unnamed tributary of Mill Creek. This tributary ranges from 10 to 15 feet in width. The banks of the channel range from gentle floodplain terraces to steep dolomite cliffs.

3.2 EVALUATION

Erosion of the spillway wall above the rock level adjacent to the dam could occur during heavy flood discharge, and such erosion would threaten the stability of the dam. Flood discharges emerging from the spillway could cause erosion of the embankment and/or the soils immediately downstream of the toe of the dam and could threaten embankment stability.

Except for wave erosion of the upstream face, no indications of slope instability were observed. However, the slopes are steep and are near the angle of repose and long-term stability of the dam cannot be determined until seepage and stability analyses are performed. The trees growing on the dam could pose a potential seepage problem along the root systems.

The embankment is a relatively porous granular structure above the tailings surface. If the water level were to rise to a sufficient depth above the tailings surface due to flood runoff, there could be significant seepage through the embankment which could adversely affect the stability of the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

No regulating procedures are known to exist for this structure. Surface water runoff would pass through an uncontrolled spillway channel on the right abutment.

4.2 MAINTENANCE OF DAM

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

4.3 MAINTENANCE OF OPERATING 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 spillway, or an increase in the volume or turbidity of water emerging from the springs downstream of the dam. A maintenance program should be initiated for the dam and spillway.

SECTION 5 - HYDRAULIC AND HYDROLOGIC ANALYSES

5.1 EVALUATION OF FEATURES

a. Design Data. The significant dimensions of the dam and spillway are presented in Section 1 - Project Information and are also in the accompanying field survey drawings, Plates 3 through 5. Hydrologic or hydraulic design information is not available.

For this evaluation, the watershed drainage area, stream lengths, and reservoir areas were measured from the 1937 7-1/2-minute USGS Tiff, Missouri Quadrangle, which has a 20-foot contour interval. The soil group for this watershed is classified as Clarksville Gravelly Loam, equivalent to a hydrologic soil group B classification, which has a moderate rate of water transmission.

The total drainage area for Lower Dresser No. 4 Dam (I.D. No. 31123) is about 600 acres (0.938 square miles). The watershed location and drainage boundary are shown on Plate 2. Dresser No. 4 Dam (I.D. No. 30474) is located 1500 feet upstream. The entire watershed can be subdivided into three parts, in downstream order, as follows:

Subarea		Incremental Drainage Area (acres)
1.	Upper Watershed	454
2.	Dresser No. 4 Dam	74
3.	Lower Dresser No. 4 Dam Area	72

Land use and vegetation pattern on the watershed were determined from field observations and aerial photographs of the area. The type of land cover and land use were used to estimate runoff curve numbers (CN) for the antecedent moisture conditions (AMC), which in turn, determine the amount of infiltration, retention losses and net runoff.

The design data, information, and assumptions used in the hydrologic and hydraulic analyses for each subarea are individually discussed below.

Subarea 1 - Upper Watershed

This area is the drainage area upstream of Dresser No. 4 Dam but excluding the area within that tailings dam. Land use and type of land cover within Subarea 1 were estimated as follows:

Type of Cover	Approximate Percent of Area
Woodlands	17
Old Mined Areas	50
Recently Mined Areas	10
Homesteads, Roads	10
Tailings (from barite mining)	13

The estimated runoff curve numbers for Subarea 1 are: AMC II, CN 54 and AMC III, CN 73.

It was assumed for these analyses that all the roads and drainage facilities within the watershed would not substantially change the time of concentration or the quantity of the flood contributions to the downstream subareas. There are only minor two-lane roads within the watershed. The old and recently mined areas within Subarea 1 are barite mining sites which left irregular scars on the topography. These areas were assigned lower runoff curve numbers in the overall weighting of the CN for Subarea 1. The computed parameters, such as lag time, unit hydrograph, probable maximum precipitation, losses and net runoff, for Subarea 1 are in Appendix A, in the computer input data and printouts as "Inflow from Upper Watershed".

Subarea 2 - Dresser No. 4 Dam

The survey information of Dresser No. 4 Dam is presented in a report entitled "Phase I Inspection Report, National Dam Safety Program, Dresser No. 4 Dam, Washington County, Missouri, MO 30474, June 1979.

This subarea is enclosed by the tailings dam. The interior of the circular embankment consists of recently disposed tailings from barite mining. The estimated runoff curve numbers are AMC II, CN 80 and AMC III, CN 97. Input data and computed parameters for Subarea 2 are in Appendix A under "Inflow from Breached Circular Embankment".

The northern part (upstream side) of the embankment was breached in August 1975 and the breach is over 300 feet wide. The tailings surface inside the impoundment slopes downward toward the north through the breach while the natural ground surface slopes downward to the south toward the impoundment and forms a topographic depression. The reservoir capacity consists of the storage available in this depression. The reservoir area-capacity data are in Appendix A. The capacities, as calculated in the computer program by the Conic Method, are the relative capacities above the minimum elevation that was entered as input and are not the total reservoir capacities at the given elevations.

The average elevation of the ground surface immediately north of the impoundment was assumed to be El. 807. Drainage from the impoundment is via a diversion ditch. The invert elevation of the ditch at its entrance was assumed to be El. 807, which is the elevation of the ground surface immediately north of the impoundment.

The channel bottom slope approaches critical slope for the beginning reach of the diversion ditch. Two methods were employed to compute the discharge rating curve for the ditch:

- Critical flows at different critical flow depths were computed using the critical flow formula.
- Manning's equation for uniform flow, using the slope of the beginning reach of the ditch as the average slope (S = 0.00822) and a Manning's "n" of 0.035.

At various depths, the discharges and velocities computed by the Manning's equation were slightly less than those computed by the critical flow formula. The results computed by the Manning's equation for uniform flow were adopted as the discharge capacities for the ditch. These are shown in Appendix A as Y4 and Y5 cards in the data input and also appear in the computer printouts with other computed parameters under "Routing from Upper Watershed and Circular Embankment to Ditch".

Subarea 3 - Lower Dresser No. 4 Dam

This subarea is the drainage area between Dresser No. 4 Dam (I.D. No. 30474) and Lower Dresser No. 4 Dam (I.D. No. 31123). Land use and type of land cover within this subarea are as follows:

Type of Cover	Approximate Percent of Area
Woodlands	46
Pasture, Roads	17
Old Mined Areas	27
Reservoir (Water and Tailings)	10

The estimated runoff curve numbers are AMC II, CN 56 and AMC III, CN 75. The reservoir (10 percent of the area) is considered to have no infiltration and retention losses during floods. This was entered into the computer program as 10 percent of the area being impervious.

Two cross-sections of the spillway channel at the spillway entrance were surveyed (see Plates 4 and 5). One section is at the embankment center-line and the other section is 10 feet upstream of the center-line. The spillway entrance is flat, and the spillway sections resemble a combination of U-shaped and V-shaped channel sections. The conventional weir flow formulas or the Manning's equation for uniform flow to compute the discharge capacities are not applicable. Therefore, computations of

the spillway discharge rating curve were based on critical flow formulas for U-shaped and V-shaped channels. The results computed for the two channel shapes were averaged to obtain the discharges and velocities at different flow depths. To obtain the reservoir water surface elevations versus spillway discharge capacities, the differences between the spillway crest elevation and the bottom elevation of the surveyed spillway sections were added to the flow depths in the spillway section. Also, the velocity head corresponding to the discharge and velocity computed at each flow depth was added to the respective flow elevations in the spillway to obtain reservoir water surface elevations. Computations of flows over the dam crest were made by the weir formula, with C = 3.0. The reservoir elevation versus discharge relationship is in Appendix A as Y4 and Y5 cards in the input data listing and in the computer printouts under the heading of "Spillway Routing from Three Watersheds through Lower Dam".

b. Experience Data. Rainfall, streamflow and flood data for the entire watershed are not available. There is no available evidence of overtopping of Lower Dresser No. 4 Dam.

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

d. Overtopping Potential. The analyses of the flow regime, flood magnitudes, flood volumes and the overtopping potential at Lower Dresser No. 4 Tailings Dam require the following successive steps:

- Compute floods for Subarea 1 - Upper Watershed.
- Compute floods for Subarea 2 - Dresser No. 4 Dam.
- Combine the computed floods for Subareas 1 and 2.
- Route the combined floods through the reservoir and diversion ditch of Dresser No. 4 Dam to obtain the total routed outflows from Subareas 1 and 2.
- Compute floods for Subarea 3 - Lower Dresser No. 4 Dam.
- Combine the routed outflows from Subareas 1 and 2 with the computed floods for Subarea 3 to obtain the total inflow into the project reservoir at Lower Dresser No. 4 Dam.
- Route the total inflow through project reservoir and spillway to determine overtopping potential.

The probable maximum flood (PMF) and floods expressed as a percent of the PMF were individually computed following the steps described above. The probable maximum flood 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.

Separate hydrologic and hydraulic analyses of Dresser No. 4 Dam (upstream) indicates that its diversion ditch cannot pass the 50 percent PMF without significant erosion of the ditch, and possibly causing further failure of the embankment along the downstream toe. Analysis of the manner in which the ditch and embankment would fail requires detailed breaching analyses, which are beyond the scope of work. Therefore, in computing the flood inflows from the upstream subareas into the Lower Dresser No. 4 Reservoir, it was assumed that Dresser No. 4 Dam and the diversion ditch would be intact and would not erode, even though separate analyses pointed to the contrary (for details, see "Phase I Inspection Report, National Dam Safety Program, Dresser No. 4 Dam, Washington County, Missouri, MO 30474, June 1979").

The computed floods were routed through the project reservoir and spillway using the Modified Puls Method of flood routing. For all cases of spillway flood routing, the starting water surface elevation was set at the spillway crest level (El. 733.4).

Results of the routing indicate that the spillway is able to pass the 100-year flood. Routing studies of floods expressed as percentages of the PMF indicate that the spillway can pass about 33 percent of the PMF without overtopping the lowest point of the embankment. However, at 33 percent PMF, the peak spillway routed outflow is about 680 cfs, with a flow depth of 3.2 feet and a flow velocity of about 7.7 feet per second. High velocities and discharges such as those at 33 percent PMF peak outflow could cause significant erosion of the spillway channel and embankment section.

A major consideration in evaluating the safety of the dam is assessing the potential for overtopping and the subsequent failure of the embankment as a result of significant erosion. Since the spillway is composed partly of erodible materials, high velocity discharges through the spillway will lead to erosion of the spillway and the 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 of the materials found in the spillway and the embankment section was estimated at about 5 feet per second. Using this as the criterion, it was estimated that the spillway can pass about 8 percent of the PMF without significant erosion. The 8 percent PMF peak routed outflow is about 80 cfs, at a flow depth of about 1.3 feet. Thus, for determining the erosion potential of the embankment, flows above 80 cfs and flow depths in the spillway higher than 1.3 feet are considered to produce the effects of significant erosion and subsequent embankment failure.

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

Flood	Peak Inflow (cfs)	Peak Outflow (cfs)	Max Res WS Elev (ft)	Spillway Flow Depth (ft)	Spillway Flow Velocity (ft/sec)	Duration Spillway Vel. over 5 ft/sec (hr)
10% PMF	199	134	735.5	1.6*	5.5*	7.2
25% PMF	540	475	737.1	2.8*	7.2*	16.3
50% PMF	1197	1114	738.1**	3.7**	8.2**	17.8
65% PMF	1572	1496	738.6**	4.0**	8.6**	19.0
80% PMF	2010	1947	739.0**	4.3**	9.0**	20.2
PMF	2584	2495	739.6**	4.3**	9.6**	23.0

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

** Dam overtopped (Minimum Dam Crest, El. 737.5).

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

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Conditions that may adversely affect the structural stability of this 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 the lack of information is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions, including earthquake loads, and should be 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 inspection team was not informed of any post-construction changes that may have been made after the dam was raised in 1975.

e. Seismic Stability. The dam is located in Seismic Zone 2, as defined in the Uniform Building Code. Some crest settlement and ravelling of the gravels could occur during seismic shaking because the gravels are loose and the downstream slope is near the natural angle of repose.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. There are several deficiencies that should be corrected. (1) Erosion protection in the spillway above the rock line, particularly adjacent to the dam, has not been provided. (2) Flood discharges emerging from the spillway could cause erosion of the embankment and/or the soils immediately downstream of the toe of the dam; this could threaten embankment stability. (3) The discharge capacity of the spillway was computed to be inadequate to pass 50 percent of the Probable Maximum Flood (PMF) without overtopping the dam and without significant erosion of the spillway 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. As an intermediate size dam with a high hazard potential, the "Recommended Guidelines for Safety Inspection of Dams" specifies that the spillway design flood for this dam should be the PMF. (4) Slope protection is lacking on the upstream face of the dam. (5) The trees growing on the dam could pose a potential seepage problem along the root systems. (6) Seepage and stability analyses were not available, and they should be made a matter of record.

b. Adequacy of Information. No detailed design or construction data were available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, and this lack of information 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 7.5-minute, 1:24,000 scale USGS quadrangle with a 20-foot contour interval. 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 apparent deficiencies in the condition of the dam and spillway. Initiation of measures to increase the spillway capacity and provide the spillway with adequate erosion protection should be given priority.

d. Necessity for Phase II. No Phase II investigation is recommended; however, additional investigative work should be done as necessary so that seepage and stability analyses can be performed. The investigations should be undertaken by a professional engineer experienced in the design and construction of tailings dams.

7.2 REMEDIAL MEASURES

The following remedial measures are recommended:

a. The spillway channel bottom is excavated into or near bedrock. However, the sides of the channel consist of clayey soil which is erosive under heavy flood discharges. Adequate erosion protection should be provided on the spillway side walls, particularly on the wall adjacent to the dam. The area where soil is above the rockline should be determined before the erosion protection is provided. The erosion protection should be adequate to withstand the peak discharge velocity resulting from the PMF. Alternatively, since bedrock appears to be near the surface, the spillway could be excavated entirely into rock.

b. The size of the downstream channel of the spillway should be enlarged and the channel should be extended a sufficient distance downstream of the dam to prevent flood discharges from eroding the embankment and/or the soils immediately downstream of the embankment toe.

c. The existing spillway capacity was calculated to be adequate to pass 8 percent of the PMF without significant erosion of the spillway and embankment and without overtopping the dam. To comply with the guidelines for a dam of this size and hazard potential, the spillway should be enlarged and/or the freeboard should be increased so that the PMF can be passed without overtopping the dam crest and without significant erosion of the spillway or embankment.

d. Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of tailings dams. The embankment is a relatively porous granular structure above the tailings surface. If the impoundment water level were to rise to a sufficient depth above the tailings surface, there could be significant seepage through the embankment which could adversely affect the stability of the dam. Included in these analyses, therefore, seepage and stability computations should also be performed with the reservoir water surface set at the top of the dam. Based on the results of the stability studies, remedial measures may become necessary. Remedial work should be done under the direction of an engineer experienced in tailings dam design and construction.

e. Adequate slope protection should be provided to prevent wave action from eroding the upstream face of the dam.

f. The channels downstream of the two springs should be kept cleared so that ponding will not occur.

g. The trees should be removed from the dam to prevent a potential seepage problem. The trees should be cleared under the guidance of an engineer experienced in the design and construction of earth dams.

h. An inspection and maintenance program should be initiated. Periodic inspections should be made by qualified personnel to observe the performance of the dam and spillway. 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. Records should be kept of these inspections and of any corrective maintenance made to the dam and spillway.

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                                          LOWER DRESSER NO. 4 (31123)
A2          HEC-1  PHASE 1 DAM SAFETY INVESTIGATION
A3          RATIOS OF PMF ROUTED THROUGH BASIN
B     268                   5                                                 2
B1      5
J       1         6         1
J1    .10       .25       .50       .65       .80       1.0
K       0   INFLOW                                      1
K1  INFLOW FROM UPPER WATERSHED
M       1         2       .71                           1                     1
P       0      25.5       102       120       130
T                                                                 -1       -73
W2                .72
X     -10        -.1       2.5
K       0   INFLOW                                      1
K1INFLOW FROM BREACHED CIRCULAR EMBANKMENT
M       1         2       .12                           1                     1
P       0      25.5       102       120       130
T                                                                 -1       -97
W2                .20
X     -10        -.1       2.5
K       2   UP+DI
K1COMBINE RUNOFF, UPPER WATERSHED AND CIRCULAR EMBANKMENT
K       1   U LAKE                              2
K1ROUTING FROM UPPER WATERSHED AND CIRCULAR EMBANKMENT
Y                                       1         1
Y1      1                                                        -807       -1
Y4    807     808.7     809.9     812.5     815.0     817.6     818.9     820.2     822.4     822.7
Y5      0        70       189       621      1359      2456      3160      4131      6157      6967
$A     30        33      46.7      73.9     118.2       159       193       219       239
$E    805       807       810       815       820       825       830       834       840
$$    807
$D  824.5
```

```
K          INFLOW                                        1
KIINFLOW FROM LOWER WATERSHED
M       1        2      .11                             1                          1
P                25.5     102      120      130
T                                                                -1      -75                .10
M2               .117
X     -10       -.1      2.5
K       2  POP+LO
KICOMBINATION OF RUNOFF FROM THREE AREAS WITHIN THE BASIN
K       1  L LAKE                        2
KISPILLWAY ROUTING, THREE WATERSHEDS THROUGH LOWER DAM
Y                                      1        1
Y1      1                                                -733.4      -1
Y4  733.4    734.1    734.7    736.0    737.3    738.6    738.9    739.5    740.5    741.0
Y5               6       34      194      535     1450     1890     2420     3920     4920
SA             3.5      7.4     10.1     13.0     16.2     20.2     24.8
SE     700     720    735.4      740      745      750      755      760
SS  733.4
SO  737.5
K      99
A
A
A
A
A
```

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

RUN  DATE= 79/06/29.
     TIME= 14.39.10.
```

LOWER DRESSER NO. 4 (31123)
HEC-1 PHASE I DAM SAFETY INVESTIGATION
RATIOS OF PMF ROUTED THROUGH BASIN

JOB SPECIFICATION

NO	NMW	NPLN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	5	0	0	0	0	0	2	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 6 LRTIO= 1

RTIOS= .10 .25 .50 .65 .80 1.00

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

SUB-AREA RUNOFF COMPUTATION

INFLOW FROM UPPER WATERSHED

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

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.71	0.00	.71	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.50	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	-73.00	0.00	0.00

CURVE NO = -73.00 WETNESS = -1.00 EFFECT CN = 73.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .72

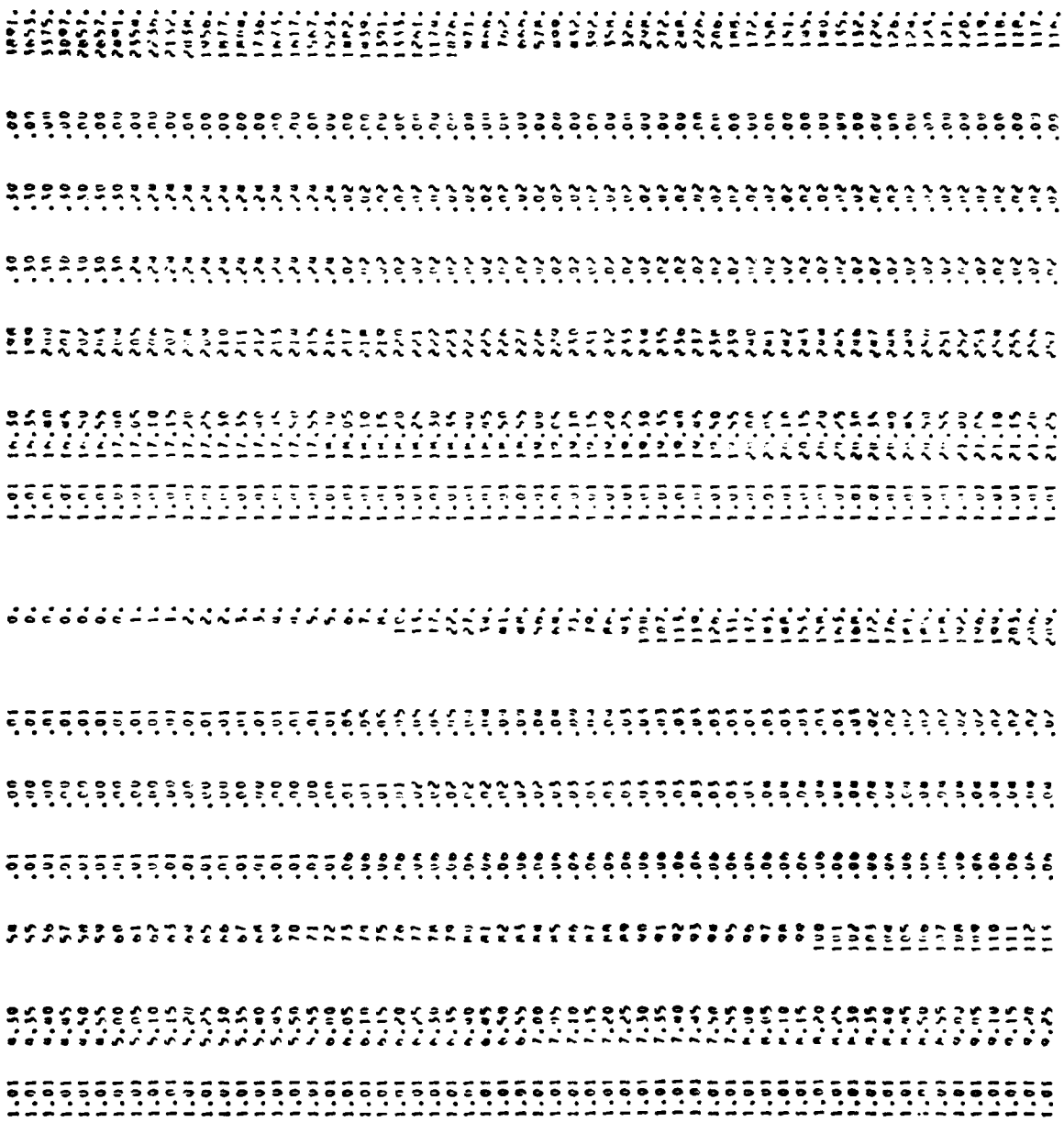
RECESSION DATA
STRTQ= -10.00 QRCSN= -.10 RTIOR= 2.50

UNIT HYDROGRAPH 85 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .72 VOL= 1.00

14.	55.	101.	167.	252.	338.	402.	439.	469.	486.
477.	382.	301.	249.	230.	191.	159.	133.	113.	95.

	88.	66.	56.	44.	39.	32.	27.	23.	19.	16.
	13.	11.	9.	8.	6.	5.	5.	4.	4.	3.
	2.	2.	1.	1.	0.					

HO.DA	HW.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	END-OF-PERIOD FLOW HO.DA	HW.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	0.	1.01	12.05	145	.22	.18	.04	275.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.10	146	.22	.18	.04	283.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.15	147	.22	.18	.04	291.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.20	148	.22	.18	.03	319.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.25	149	.22	.18	.03	353.
1.01	.30	6	.01	0.00	.01	0.	1.01	12.30	150	.22	.19	.03	397.
1.01	.35	7	.01	0.00	.01	0.	1.01	12.35	151	.22	.19	.03	450.
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.22	.19	.03	508.
1.01	.45	9	.01	0.00	.01	0.	1.01	12.45	153	.22	.19	.03	568.
1.01	.50	10	.01	0.00	.01	0.	1.01	12.50	154	.22	.19	.03	628.
1.01	.55	11	.01	0.00	.01	0.	1.01	12.55	155	.22	.19	.03	685.
1.01	1.00	12	.01	0.00	.01	0.	1.01	13.00	156	.22	.19	.02	739.
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.05	157	.26	.23	.03	788.
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.10	158	.26	.23	.03	832.
1.01	1.15	15	.01	0.00	.01	0.	1.01	13.15	159	.26	.23	.03	871.
1.01	1.20	16	.01	0.00	.01	0.	1.01	13.20	160	.26	.24	.02	907.
1.01	1.25	17	.01	0.00	.01	0.	1.01	13.25	161	.26	.24	.02	943.
1.01	1.30	18	.01	0.00	.01	0.	1.01	13.30	162	.26	.24	.02	979.
1.01	1.35	19	.01	0.00	.01	0.	1.01	13.35	163	.26	.24	.02	1014.
1.01	1.40	20	.01	0.00	.01	0.	1.01	13.40	164	.26	.24	.02	1049.
1.01	1.45	21	.01	0.00	.01	0.	1.01	13.45	165	.26	.24	.02	1083.
1.01	1.50	22	.01	0.00	.01	0.	1.01	13.50	166	.26	.24	.02	1114.
1.01	1.55	23	.01	0.00	.01	0.	1.01	13.55	167	.26	.24	.02	1143.
1.01	2.00	24	.01	0.00	.01	0.	1.01	14.00	168	.26	.24	.02	1169.
1.01	2.05	25	.01	0.00	.01	0.	1.01	14.05	169	.33	.30	.02	1194.
1.01	2.10	26	.01	0.00	.01	0.	1.01	14.10	170	.33	.30	.02	1218.
1.01	2.15	27	.01	0.00	.01	0.	1.01	14.15	171	.33	.31	.02	1242.
1.01	2.20	28	.01	0.00	.01	0.	1.01	14.20	172	.33	.31	.02	1267.
1.01	2.25	29	.01	0.00	.01	0.	1.01	14.25	173	.33	.31	.02	1296.
1.01	2.30	30	.01	0.00	.01	0.	1.01	14.30	174	.33	.31	.02	1329.
1.01	2.35	31	.01	0.00	.01	0.	1.01	14.35	175	.33	.31	.02	1364.
1.01	2.40	32	.01	0.00	.01	0.	1.01	14.40	176	.33	.31	.02	1401.
1.01	2.45	33	.01	0.00	.01	0.	1.01	14.45	177	.33	.31	.02	1437.
1.01	2.50	34	.01	0.00	.01	0.	1.01	14.50	178	.33	.31	.01	1472.
1.01	2.55	35	.01	0.00	.01	0.	1.01	14.55	179	.33	.31	.01	1505.
1.01	3.00	36	.01	0.00	.01	0.	1.01	15.00	180	.33	.31	.01	1535.
1.01	3.05	37	.01	0.00	.01	0.	1.01	15.05	181	.40	.36	.01	1560.
1.01	3.10	38	.01	0.00	.01	0.	1.01	15.10	182	.40	.38	.02	1580.
1.01	3.15	39	.01	0.00	.01	0.	1.01	15.15	183	.40	.38	.02	1597.
1.01	3.20	40	.01	0.00	.01	0.	1.01	15.20	184	.50	.47	.02	1614.
1.01	3.25	41	.01	0.00	.01	0.	1.01	15.25	185	.69	.67	.02	1643.
1.01	3.30	42	.01	0.00	.01	0.	1.01	15.30	186	1.68	1.63	.05	1702.
1.01	3.35	43	.01	0.00	.01	0.	1.01	15.35	187	2.77	2.70	.07	1838.
1.01	3.40	44	.01	0.00	.01	0.	1.01	15.40	188	1.09	1.06	.02	2040.
1.01	3.45	45	.01	0.00	.01	0.	1.01	15.45	189	.69	.68	.01	2161.
1.01	3.50	46	.01	0.00	.01	0.	1.01	15.50	190	.59	.58	.01	2741.
1.01	3.55	47	.01	0.00	.01	0.	1.01	15.55	191	.40	.39	.01	3178.
1.01	4.00	48	.01	0.00	.01	0.	1.01	16.00	192	.40	.39	.01	3505.
1.01	4.05	49	.01	0.00	.01	0.	1.01	16.05	193	.30	.30	.01	3928.
1.01	4.10	50	.01	0.00	.01	0.	1.01	16.10	194	.30	.30	.01	4133.
1.01	4.15	51	.01	0.00	.01	0.	1.01	16.15	195	.30	.30	.00	4222.
1.01	4.20	52	.01	0.00	.01	0.	1.01	16.20	196	.30	.30	.00	4283.
1.01	4.25	53	.01	.00	.01	0.	1.01	16.25	197	.30	.30	.00	4070.



1.01	9.50	114	.06	.04	.02	212.	1.01	21.30	258	.02	.02	.00	116.
1.01	9.55	115	.06	.04	.02	215.	1.01	21.35	259	.02	.02	.00	116.
1.01	9.60	116	.06	.04	.02	218.	1.01	21.40	260	.02	.02	.00	116.
1.01	9.65	117	.06	.04	.02	221.	1.01	21.45	261	.02	.02	.00	115.
1.01	9.70	118	.06	.05	.02	224.	1.01	21.50	262	.02	.02	.00	115.
1.01	9.75	119	.06	.05	.02	226.	1.01	21.55	263	.02	.02	.00	115.
1.01	10.00	120	.06	.05	.02	229.	1.01	22.00	264	.02	.02	.00	115.
1.01	10.05	121	.06	.05	.02	231.	1.01	22.05	265	.02	.02	.00	116.
1.01	10.10	122	.06	.05	.02	234.	1.01	22.10	266	.02	.02	.00	116.
1.01	10.15	123	.06	.05	.02	236.	1.01	22.15	267	.02	.02	.00	116.
1.01	10.20	124	.06	.05	.02	238.	1.01	22.20	268	.02	.02	.00	116.
1.01	10.25	125	.06	.05	.02	240.	1.01	22.25	269	.02	.02	.00	116.
1.01	10.30	126	.06	.05	.02	242.	1.01	22.30	270	.02	.02	.00	116.
1.01	10.35	127	.06	.05	.02	244.	1.01	22.35	271	.02	.02	.00	116.
1.01	10.40	128	.06	.05	.02	246.	1.01	22.40	272	.02	.02	.00	116.
1.01	10.45	129	.06	.05	.02	248.	1.01	22.45	273	.02	.02	.00	116.
1.01	10.50	130	.06	.05	.01	250.	1.01	22.50	274	.02	.02	.00	116.
1.01	10.55	131	.06	.05	.01	252.	1.01	22.55	275	.02	.02	.00	116.
1.01	11.00	132	.06	.05	.01	254.	1.01	23.00	276	.02	.02	.00	116.
1.01	11.05	133	.06	.05	.01	256.	1.01	23.05	277	.02	.02	.00	116.
1.01	11.10	134	.06	.05	.01	257.	1.01	23.10	278	.02	.02	.00	116.
1.01	11.15	135	.06	.05	.01	259.	1.01	23.15	279	.02	.02	.00	116.
1.01	11.20	136	.06	.05	.01	260.	1.01	23.20	280	.02	.02	.00	116.
1.01	11.25	137	.06	.05	.01	262.	1.01	23.25	281	.02	.02	.00	116.
1.01	11.30	138	.06	.05	.01	264.	1.01	23.30	282	.02	.02	.00	116.
1.01	11.35	139	.06	.05	.01	265.	1.01	23.35	283	.02	.02	.00	116.
1.01	11.40	140	.06	.05	.01	266.	1.01	23.40	284	.02	.02	.00	116.
1.01	11.45	141	.06	.05	.01	268.	1.01	23.45	285	.02	.02	.00	116.
1.01	11.50	142	.06	.05	.01	269.	1.01	23.50	286	.02	.02	.00	116.
1.01	11.55	143	.06	.05	.01	271.	1.01	23.55	287	.02	.02	.00	116.
1.01	12.00	144	.06	.05	.01	272.	1.02	0.00	288	.02	.02	.00	116.
									SUM	33.15	29.09	4.06	158905.
										(842.)(739.)(103.)(4499.69)			

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	8222.	1832.	552.	552.	158836.
CMS	120.	52.	16.	16.	4498.
INCHES		28.00	28.90	28.90	28.90
MM		609.57	734.15	734.15	734.15
AC-FT		908.	1094.	1094.	1094.
THOUS CU M		1120.	1349.	1349.	1349.

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

SUB-AREA RUNOFF COMPUTATION

INFLOW FROM BREACHED CIRCULAR EMBANKMENT

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO

INFLOW 0 0 0 0 1 0 0 0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.12	0.00	.12	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.50	102.00	120.00	130.00	0.00	0.00	0.00

LOSS DATA

LRDPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOR	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-97.00	0.00	0.00

CURVE NO = -97.00 RETNESS = -1.00 EFFECT CN = 97.00

UNIT HYDROGRAPH DATA

TC= 0.00 LAG= .20

RECESSION DATA

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

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

58. 193. 239. 191. 108. 61. 35. 20. 11. 6.
4. 2. 1. 0.

0 MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	1.	1.01	12.05	145	.22	.22	.00	68.
1.01	.10	2	.01	0.00	.01	1.	1.01	12.10	146	.22	.22	.00	97.
1.01	.15	3	.01	0.00	.01	1.	1.01	12.15	147	.22	.22	.00	134.
1.01	.20	4	.01	0.00	.01	1.	1.01	12.20	148	.22	.22	.00	163.
1.01	.25	5	.01	.00	.01	1.	1.01	12.25	149	.22	.22	.00	179.
1.01	.30	6	.01	.00	.01	1.	1.01	12.30	150	.22	.22	.00	189.
1.01	.35	7	.01	.00	.01	1.	1.01	12.35	151	.22	.22	.00	194.
1.01	.40	8	.01	.00	.01	2.	1.01	12.40	152	.22	.22	.00	197.
1.01	.45	9	.01	.00	.01	2.	1.01	12.45	153	.22	.22	.00	199.
1.01	.50	10	.01	.00	.01	3.	1.01	12.50	154	.22	.22	.00	200.
1.01	.55	11	.01	.01	.01	4.	1.01	12.55	155	.22	.22	.00	200.
1.01	1.00	12	.01	.01	.01	4.	1.01	13.00	156	.22	.22	.00	201.
1.01	1.05	13	.01	.01	.01	5.	1.01	13.05	157	.26	.26	.00	205.
1.01	1.10	14	.01	.01	.01	6.	1.01	13.10	158	.26	.26	.00	212.
1.01	1.15	15	.01	.01	.01	6.	1.01	13.15	159	.26	.26	.00	222.
1.01	1.20	16	.01	.01	.01	6.	1.01	13.20	160	.26	.26	.00	231.
1.01	1.25	17	.01	.01	.01	7.	1.01	13.25	161	.26	.26	.00	235.
1.01	1.30	18	.01	.01	.01	7.	1.01	13.30	162	.26	.26	.00	238.
1.01	1.35	19	.01	.01	.01	8.	1.01	13.35	163	.26	.26	.00	239.
1.01	1.40	20	.01	.01	.00	8.	1.01	13.40	164	.26	.26	.00	240.
1.01	1.45	21	.01	.01	.00	8.	1.01	13.45	165	.26	.26	.00	241.
1.01	1.50	22	.01	.01	.00	8.	1.01	13.50	166	.26	.26	.00	241.
1.01	1.55	23	.01	.01	.00	9.	1.01	13.55	167	.26	.26	.00	241.
1.01	2.00	24	.01	.01	.00	9.	1.01	14.00	168	.26	.26	.00	241.
1.01	2.05	25	.01	.01	.00	9.	1.01	14.05	169	.33	.32	.00	245.
1.01	2.10	26	.01	.01	.00	9.	1.01	14.10	170	.33	.32	.00	254.
1.01	2.15	27	.01	.01	.00	10.	1.01	14.15	171	.33	.32	.00	265.
1.01	2.20	28	.01	.01	.00	10.	1.01	14.20	172	.33	.32	.00	274.
1.01	2.25	29	.01	.01	.00	10.	1.01	14.25	173	.33	.32	.00	281.
1.01	2.30	30	.01	.01	.00	10.	1.01	14.30	174	.33	.32	.00	287.
1.01	2.35	31	.01	.01	.00	10.	1.01	14.35	175	.33	.32	.00	290.

1.01	2.40	52	.01	.01	.00	10.	1.01	14.40	176	.55	.52	.00	300.
1.01	2.45	53	.01	.01	.00	10.	1.01	14.45	177	.55	.52	.00	301.
1.01	2.50	54	.01	.01	.00	10.	1.01	14.50	178	.55	.52	.00	301.
1.01	2.55	55	.01	.01	.00	11.	1.01	14.55	179	.55	.52	.00	302.
1.01	2.60	56	.01	.01	.00	11.	1.01	15.00	180	.55	.52	.00	302.
1.01	2.65	57	.01	.01	.00	11.	1.01	15.05	181	.20	.20	.00	290.
1.01	2.70	58	.01	.01	.00	11.	1.01	15.10	182	.40	.40	.00	281.
1.01	2.75	59	.01	.01	.00	11.	1.01	15.15	183	.40	.40	.00	289.
1.01	2.80	60	.01	.01	.00	11.	1.01	15.20	184	.59	.59	.00	323.
1.01	2.85	61	.01	.01	.00	11.	1.01	15.25	185	.69	.69	.00	392.
1.01	2.90	62	.01	.01	.00	11.	1.01	15.30	186	1.08	1.08	.00	529.
1.01	2.95	63	.01	.01	.00	11.	1.01	15.35	187	2.77	2.77	.00	852.
1.01	3.00	64	.01	.01	.00	11.	1.01	15.40	188	1.09	1.09	.00	1266.
1.01	3.05	65	.01	.01	.00	11.	1.01	15.45	189	.69	.69	.00	1371.
1.01	3.10	66	.01	.01	.00	11.	1.01	15.50	190	.59	.59	.00	1214.
1.01	3.15	67	.01	.01	.00	11.	1.01	15.55	191	.40	.40	.00	952.
1.01	3.20	68	.01	.01	.00	12.	1.01	16.00	192	.40	.40	.00	742.
1.01	3.25	69	.01	.01	.00	12.	1.01	16.05	193	.30	.30	.00	585.
1.01	3.30	70	.01	.01	.00	12.	1.01	16.10	194	.30	.30	.00	472.
1.01	3.35	71	.01	.01	.00	12.	1.01	16.15	195	.30	.30	.00	395.
1.01	3.40	72	.01	.01	.00	12.	1.01	16.20	196	.30	.30	.00	346.
1.01	3.45	73	.01	.01	.00	12.	1.01	16.25	197	.30	.30	.00	314.
1.01	3.50	74	.01	.01	.00	12.	1.01	16.30	198	.30	.30	.00	301.
1.01	3.55	75	.01	.01	.00	12.	1.01	16.35	199	.30	.30	.00	295.
1.01	3.60	76	.01	.01	.00	12.	1.01	16.40	200	.30	.30	.00	287.
1.01	3.65	77	.01	.01	.00	12.	1.01	16.45	201	.30	.30	.00	284.
1.01	3.70	78	.01	.01	.00	12.	1.01	16.50	202	.30	.30	.00	283.
1.01	3.75	79	.01	.01	.00	12.	1.01	16.55	203	.30	.30	.00	282.
1.01	3.80	80	.01	.01	.00	12.	1.01	17.00	204	.30	.30	.00	282.
1.01	3.85	81	.01	.01	.00	12.	1.01	17.05	205	.24	.24	.00	278.
1.01	3.90	82	.01	.01	.00	12.	1.01	17.10	206	.24	.24	.00	265.
1.01	3.95	83	.01	.01	.00	12.	1.01	17.15	207	.24	.24	.00	250.
1.01	4.00	84	.01	.01	.00	12.	1.01	17.20	208	.24	.24	.00	238.
1.01	4.05	85	.01	.01	.00	12.	1.01	17.25	209	.24	.24	.00	231.
1.01	4.10	86	.01	.01	.00	12.	1.01	17.30	210	.24	.24	.00	227.
1.01	4.15	87	.01	.01	.00	12.	1.01	17.35	211	.24	.24	.00	224.
1.01	4.20	88	.01	.01	.00	12.	1.01	17.40	212	.24	.24	.00	223.
1.01	4.25	89	.01	.01	.00	12.	1.01	17.45	213	.24	.24	.00	222.
1.01	4.30	90	.01	.01	.00	12.	1.01	17.50	214	.24	.24	.00	222.
1.01	4.35	91	.01	.01	.00	12.	1.01	17.55	215	.24	.24	.00	222.
1.01	4.40	92	.01	.01	.00	12.	1.01	18.00	216	.24	.24	.00	222.
1.01	4.45	93	.00	.00	.00	15.	1.01	18.05	217	.02	.02	.00	209.
1.01	4.50	94	.00	.00	.00	24.	1.01	18.10	218	.02	.02	.00	167.
1.01	4.55	95	.00	.00	.00	35.	1.01	18.15	219	.02	.02	.00	132.
1.01	4.60	96	.00	.00	.00	45.	1.01	18.20	220	.02	.02	.00	120.
1.01	4.65	97	.00	.00	.00	50.	1.01	18.25	221	.02	.02	.00	110.
1.01	4.70	98	.00	.00	.00	53.	1.01	18.30	222	.02	.02	.00	100.
1.01	4.75	99	.00	.00	.00	55.	1.01	18.35	223	.02	.02	.00	91.
1.01	4.80	00	.00	.00	.00	56.	1.01	18.40	224	.02	.02	.00	83.
1.01	4.85	01	.00	.00	.00	56.	1.01	18.45	225	.02	.02	.00	76.
1.01	4.90	02	.00	.00	.00	57.	1.01	18.50	226	.02	.02	.00	69.
1.01	4.95	03	.00	.00	.00	57.	1.01	18.55	227	.02	.02	.00	63.
1.01	5.00	04	.00	.00	.00	57.	1.01	19.00	228	.02	.02	.00	58.
1.01	5.05	05	.00	.00	.00	58.	1.01	19.05	229	.02	.02	.00	53.
1.01	5.10	06	.00	.00	.00	58.	1.01	19.10	230	.02	.02	.00	48.
1.01	5.15	07	.00	.00	.00	58.	1.01	19.15	231	.02	.02	.00	44.
1.01	5.20	08	.00	.00	.00	58.	1.01	19.20	232	.02	.02	.00	40.
1.01	5.25	09	.00	.00	.00	58.	1.01	19.25	233	.02	.02	.00	37.
1.01	5.30	10	.00	.00	.00	58.	1.01	19.30	234	.02	.02	.00	33.
1.01	5.35	11	.00	.00	.00	58.	1.01	19.35	235	.02	.02	.00	30.

1.01	7.40	92	.08	.08	.00	50.	1.01	19.40	236	.02	.02	.00	20.
1.01	7.45	93	.08	.08	.00	50.	1.01	19.45	237	.02	.02	.00	20.
1.01	7.50	94	.08	.08	.00	50.	1.01	19.50	238	.02	.02	.00	20.
1.01	7.55	95	.08	.08	.00	50.	1.01	19.55	239	.02	.02	.00	20.
1.01	8.00	96	.08	.08	.00	50.	1.01	20.00	240	.02	.02	.00	20.
1.01	8.05	97	.08	.08	.00	50.	1.01	20.05	241	.02	.02	.00	20.
1.01	8.10	98	.08	.08	.00	50.	1.01	20.10	242	.02	.02	.00	20.
1.01	8.15	99	.08	.08	.00	50.	1.01	20.15	243	.02	.02	.00	20.
1.01	8.20	100	.08	.08	.00	50.	1.01	20.20	244	.02	.02	.00	20.
1.01	8.25	101	.08	.08	.00	50.	1.01	20.25	245	.02	.02	.00	20.
1.01	8.30	102	.08	.08	.00	50.	1.01	20.30	246	.02	.02	.00	20.
1.01	8.35	103	.08	.08	.00	50.	1.01	20.35	247	.02	.02	.00	20.
1.01	8.40	104	.08	.08	.00	50.	1.01	20.40	248	.02	.02	.00	20.
1.01	8.45	105	.08	.08	.00	50.	1.01	20.45	249	.02	.02	.00	20.
1.01	8.50	106	.08	.08	.00	50.	1.01	20.50	250	.02	.02	.00	20.
1.01	8.55	107	.08	.08	.00	50.	1.01	20.55	251	.02	.02	.00	20.
1.01	9.00	108	.08	.08	.00	50.	1.01	21.00	252	.02	.02	.00	20.
1.01	9.05	109	.08	.08	.00	50.	1.01	21.05	253	.02	.02	.00	20.
1.01	9.10	110	.08	.08	.00	50.	1.01	21.10	254	.02	.02	.00	20.
1.01	9.15	111	.08	.08	.00	50.	1.01	21.15	255	.02	.02	.00	20.
1.01	9.20	112	.08	.08	.00	50.	1.01	21.20	256	.02	.02	.00	20.
1.01	9.25	113	.08	.08	.00	50.	1.01	21.25	257	.02	.02	.00	20.
1.01	9.30	114	.08	.08	.00	50.	1.01	21.30	258	.02	.02	.00	20.
1.01	9.35	115	.08	.08	.00	50.	1.01	21.35	259	.02	.02	.00	20.
1.01	9.40	116	.08	.08	.00	50.	1.01	21.40	260	.02	.02	.00	20.
1.01	9.45	117	.08	.08	.00	50.	1.01	21.45	261	.02	.02	.00	20.
1.01	9.50	118	.08	.08	.00	50.	1.01	21.50	262	.02	.02	.00	20.
1.01	9.55	119	.08	.08	.00	50.	1.01	21.55	263	.02	.02	.00	20.
1.01	10.00	120	.08	.08	.00	50.	1.01	22.00	264	.02	.02	.00	20.
1.01	10.05	121	.08	.08	.00	50.	1.01	22.05	265	.02	.02	.00	20.
1.01	10.10	122	.08	.08	.00	50.	1.01	22.10	266	.02	.02	.00	20.
1.01	10.15	123	.08	.08	.00	50.	1.01	22.15	267	.02	.02	.00	20.
1.01	10.20	124	.08	.08	.00	50.	1.01	22.20	268	.02	.02	.00	20.
1.01	10.25	125	.08	.08	.00	50.	1.01	22.25	269	.02	.02	.00	20.
1.01	10.30	126	.08	.08	.00	50.	1.01	22.30	270	.02	.02	.00	20.
1.01	10.35	127	.08	.08	.00	50.	1.01	22.35	271	.02	.02	.00	20.
1.01	10.40	128	.08	.08	.00	50.	1.01	22.40	272	.02	.02	.00	20.
1.01	10.45	129	.08	.08	.00	50.	1.01	22.45	273	.02	.02	.00	20.
1.01	10.50	130	.08	.08	.00	50.	1.01	22.50	274	.02	.02	.00	20.
1.01	10.55	131	.08	.08	.00	50.	1.01	22.55	275	.02	.02	.00	20.
1.01	11.00	132	.08	.08	.00	50.	1.01	23.00	276	.02	.02	.00	20.
1.01	11.05	133	.08	.08	.00	50.	1.01	23.05	277	.02	.02	.00	20.
1.01	11.10	134	.08	.08	.00	50.	1.01	23.10	278	.02	.02	.00	20.
1.01	11.15	135	.08	.08	.00	50.	1.01	23.15	279	.02	.02	.00	20.
1.01	11.20	136	.08	.08	.00	50.	1.01	23.20	280	.02	.02	.00	20.
1.01	11.25	137	.08	.08	.00	50.	1.01	23.25	281	.02	.02	.00	20.
1.01	11.30	138	.08	.08	.00	50.	1.01	23.30	282	.02	.02	.00	20.
1.01	11.35	139	.08	.08	.00	50.	1.01	23.35	283	.02	.02	.00	20.
1.01	11.40	140	.08	.08	.00	50.	1.01	23.40	284	.02	.02	.00	20.
1.01	11.45	141	.08	.08	.00	50.	1.01	23.45	285	.02	.02	.00	20.
1.01	11.50	142	.08	.08	.00	50.	1.01	23.50	286	.02	.02	.00	20.
1.01	11.55	143	.08	.08	.00	50.	1.01	23.55	287	.02	.02	.00	20.
1.01	12.00	144	.08	.08	.00	50.	1.02	0.00	288	.02	.02	.00	20.
									SUM	33.15	32.78	.37	31075.
										(842.1(	832.3(	9.3(	879.95)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1571.	332.	104.	104.	31050.
CMS	44.	9.	3.	3.	879.

INCHES	25.79	33.43	33.43		33.43
MM	653.83	849.12	849.12		849.12
AC-FT	165.	214.	214.		214.
THOUS CU M	203.	264.	264.		264.

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COMBINE HYDROGRAPHS

COMBINE RUNOFF, UPPER WATERSHED AND CIRCULAR EMBANKMENT

	ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
	UP+DI	2	0	0	0	0	0	0	0

SUM OF 2 HYDROGRAPHS AT UP+DI PLAN 1 RTIO 6

6.	7.	7.	7.	8.	8.	8.	9.	9.	9.
9.	9.	10.	10.	10.	10.	10.	10.	10.	10.
11.	11.	11.	11.	11.	11.	11.	11.	11.	11.
11.	11.	11.	11.	11.	12.	12.	12.	12.	12.
12.	12.	12.	12.	12.	12.	12.	12.	12.	12.
13.	13.	13.	14.	14.	14.	15.	15.	16.	16.
17.	17.	21.	31.	83.	58.	63.	70.	76.	83.
90.	98.	106.	113.	121.	129.	137.	144.	151.	158.
165.	171.	178.	184.	190.	196.	201.	206.	212.	217.
221.	226.	231.	235.	239.	243.	247.	251.	255.	258.
261.	265.	268.	271.	274.	277.	280.	282.	285.	288.
290.	292.	295.	297.	299.	301.	303.	305.	307.	309.
311.	313.	315.	316.	318.	319.	321.	323.	324.	325.
327.	328.	330.	331.	343.	380.	431.	482.	532.	576.
644.	705.	767.	828.	886.	939.	991.	1043.	1093.	1138.
1378.	1217.	1254.	1290.	1324.	1355.	1384.	1411.	1439.	1474.
1515.	1553.	1592.	1625.	1663.	1701.	1738.	1775.	1806.	1837.
1858.	1881.	1886.	1939.	2038.	2231.	2690.	3304.	3731.	3955.
4150.	4337.	4509.	4685.	4817.	4509.	4397.	4193.	3986.	3842.
3581.	3180.	2934.	2772.	2632.	2501.	2382.	2276.	2186.	2108.
2028.	1959.	1896.	1839.	1789.	1745.	1691.	1606.	1523.	1458.
1371.	1274.	1167.	1055.	982.	832.	729.	636.	552.	480.
436.	398.	363.	331.	302.	276.	252.	230.	209.	192.
178.	170.	168.	159.	155.	152.	149.	146.	144.	142.
141.	140.	139.	138.	137.	137.	136.	136.	135.	135.
135.	135.	135.	135.	135.	135.	135.	135.	135.	135.
135.	135.	135.	135.	135.	135.	135.	135.	135.	135.
135.	135.	135.	135.	135.	135.	135.	135.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4617.	2155.	659.	659.	189886.
CMS	131.	61.	19.	19.	5377.
INCHES		24.15	29.56	29.56	29.56
MM		613.35	750.77	750.77	750.77
AC-FT		1088.	1308.	1308.	1308.
THOUS CU M		1318.	1613.	1613.	1613.

HYDROGRAPH ROUTING

ROUTING FROM UPPER WATERSHED AND CIRCULAR EMBANKMENT

ISTAQ	ICOMP	ICON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
U LAKE	1	0	0	2	0	0	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IPES	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	-807.	-1

ELEV	807.00	808.70	809.90	812.50	815.00	817.60	818.90	820.20	822.40	822.70
FLOW	0.00	70.00	189.00	621.00	1359.00	2456.00	3160.00	4131.00	6157.00	6967.00
SURFACE AREA=	30.	33.	47.	74.	118.	159.	193.	219.	239.	
CAPACITY=	0.	63.	182.	481.	957.	1647.	2526.	3349.	4723.	
ELEVATION=	805.	807.	810.	815.	820.	825.	830.	834.	840.	

CREL	SPWID	COOM	EXPW	ELEVL	COOL	CAREA	EXPL
807.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
824.5	0.0	0.0	0.

STATION U LAKE, PLAN 1, RATIO 6

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	4.	4.	4.	4.	4.	4.	4.
4.	4.	4.	4.	4.	4.	5.	5.	5.	5.
5.	5.	5.	5.	6.	6.	7.	7.	8.	
9.	9.	10.	11.	12.	13.	14.	15.	16.	17.
18.	19.	21.	22.	23.	25.	26.	27.	29.	30.
32.	33.	35.	36.	38.	39.	41.	42.	44.	46.
47.	49.	50.	52.	54.	55.	57.	58.	60.	62.
63.	65.	66.	68.	70.	73.	77.	81.	84.	88.
92.	95.	99.	102.	106.	109.	113.	116.	119.	122.
126.	129.	132.	135.	138.	142.	146.	150.	156.	162.
169.	176.	184.	196.	212.	229.	247.	265.	283.	302.
322.	341.	361.	381.	401.	421.	441.	461.	481.	501.
521.	541.	562.	582.	603.	625.	662.	698.	735.	765.
803.	836.	868.	901.	934.	971.	1015.	1074.	1145.	1222.
1301.	1390.	1504.	1615.	1723.	1823.	1914.	1994.	2062.	2118.
2163.	2198.	2225.	2244.	2259.	2268.	2274.	2275.	2274.	2270.
2264.	2255.	2245.	2233.	2220.	2206.	2190.	2173.	2154.	2132.
2109.	2084.	2056.	2025.	1991.	1954.	1915.	1873.	1829.	1784.
1737.	1691.	1644.	1597.	1550.	1503.	1457.	1411.	1365.	1332.
1300.	1269.	1238.	1208.	1178.	1149.	1120.	1092.	1064.	1037.
1010.	984.	959.	934.	909.	885.	862.	839.	817.	796.
775.	754.	734.	715.	696.	677.	659.	642.	625.	610.
605.	596.	587.	578.	570.	561.	553.	544.	536.	528.
520.	513.	505.	498.	490.	483.	476.	469.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2275.	1675.	559.	559.	160971.
CMS	64.	47.	16.	16.	4558.
INCHES		18.77	25.06	25.06	25.06
MM		476.76	636.45	636.45	636.45
AC-FT		830.	1109.	1109.	1109.
THOUS CU M		1024.	1367.	1367.	1367.

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 .10	RATIO 2 .25	RATIO 3 .50	RATIO 4 .65	RATIO 5 .80	RATIO 6 1.00
HYDROGRAPH AT	INFLOW	.71	1	422.	1055.	2111.	2744.	3378.	4222.
		(1.84)		(11.96)(	29.89)(	59.78)(	77.71)(	95.64)(	119.55)(
HYDROGRAPH AT	INFLOW	.12	1	137.	343.	685.	891.	1096.	1371.
		(.31)		(3.88)(	9.70)(	19.41)(	25.23)(	31.05)(	38.81)(
2 COMBINED	UP+DI	.83	1	462.	1154.	2308.	3001.	3694.	4617.
		(2.15)		(13.07)(	32.68)(	65.37)(	84.98)(	104.59)(	130.74)(
ROUTED TO	U LAKE	.83	1	126.	433.	1015.	1365.	1782.	2275.
		(2.15)		(3.57)(	12.26)(	28.75)(	38.67)(	50.46)(	64.43)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	807.00	807.00	824.50
STORAGE	63.	63.	1569.
OUTFLOW	0.	0.	11827.

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
.10	809.27	0.00	149.	126.	0.00	18.50	0.00
.25	811.37	0.00	250.	433.	0.00	18.00	0.00
.50	813.84	0.00	399.	1015.	0.00	17.58	0.00
.65	815.02	0.00	482.	1365.	0.00	17.50	0.00
.80	816.00	0.00	559.	1782.	0.00	17.42	0.00
1.00	817.17	0.00	661.	2275.	0.00	17.33	0.00

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SUB-AREA RUNOFF COMPUTATION

INFLOW FROM LOWER WATERSHED

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

HYDROGRAPH DATA

IHYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.11	0.00	.11	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.50	102.00	120.00	130.00	0.00	0.00	0.00

LOSS DATA

LRUPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOR	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-75.00	0.00	.10

CURVE NO = -75.00 HYDIESS = -1.00 EFFECT CN = 75.00

UNIT HYDROGRAPH DATA

TC= 0.00 LAG= .12

RECESSION DATA

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

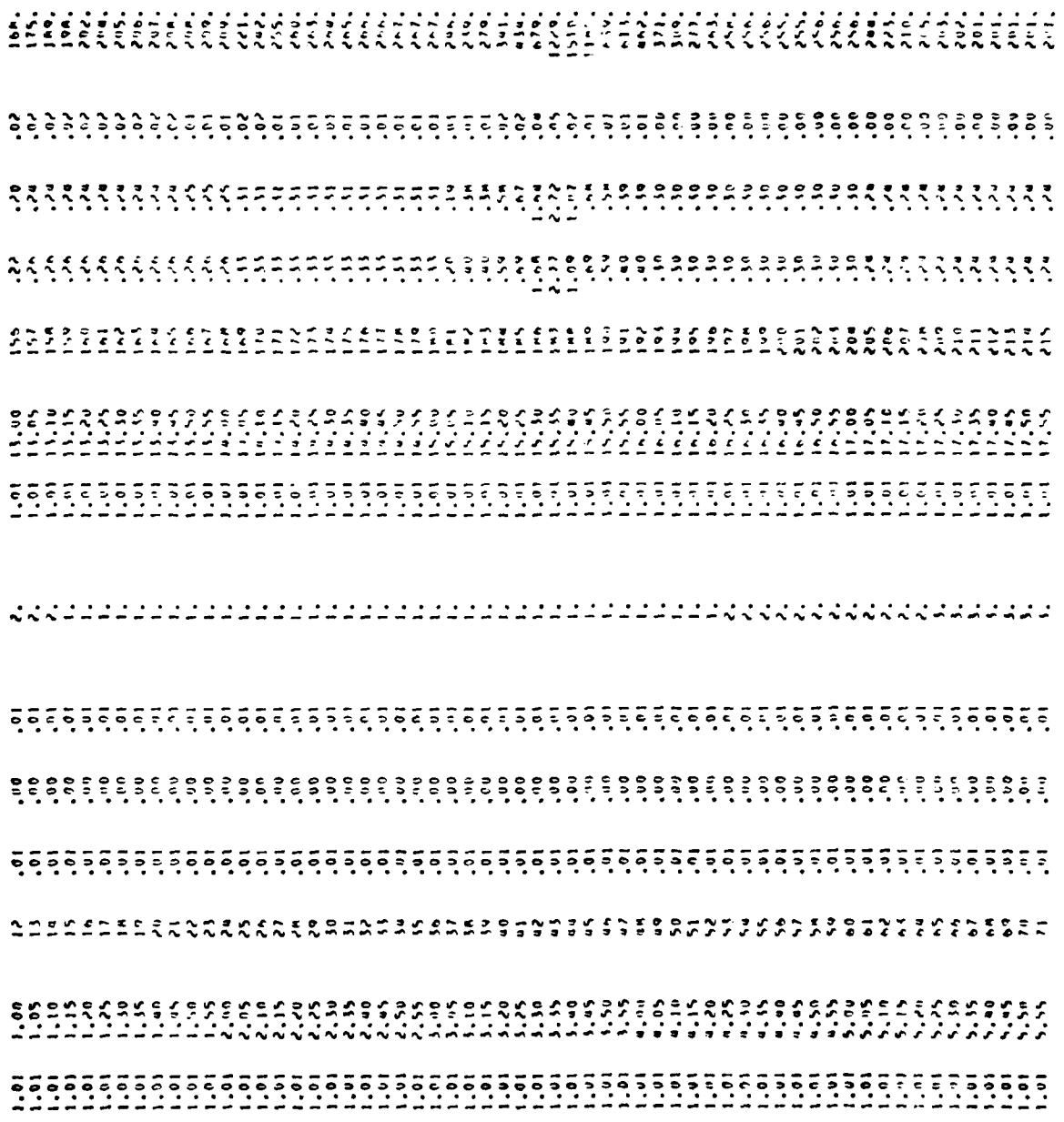
TIME INCREMENT TOO LARGE--(DTHR IS GT LAG/2)

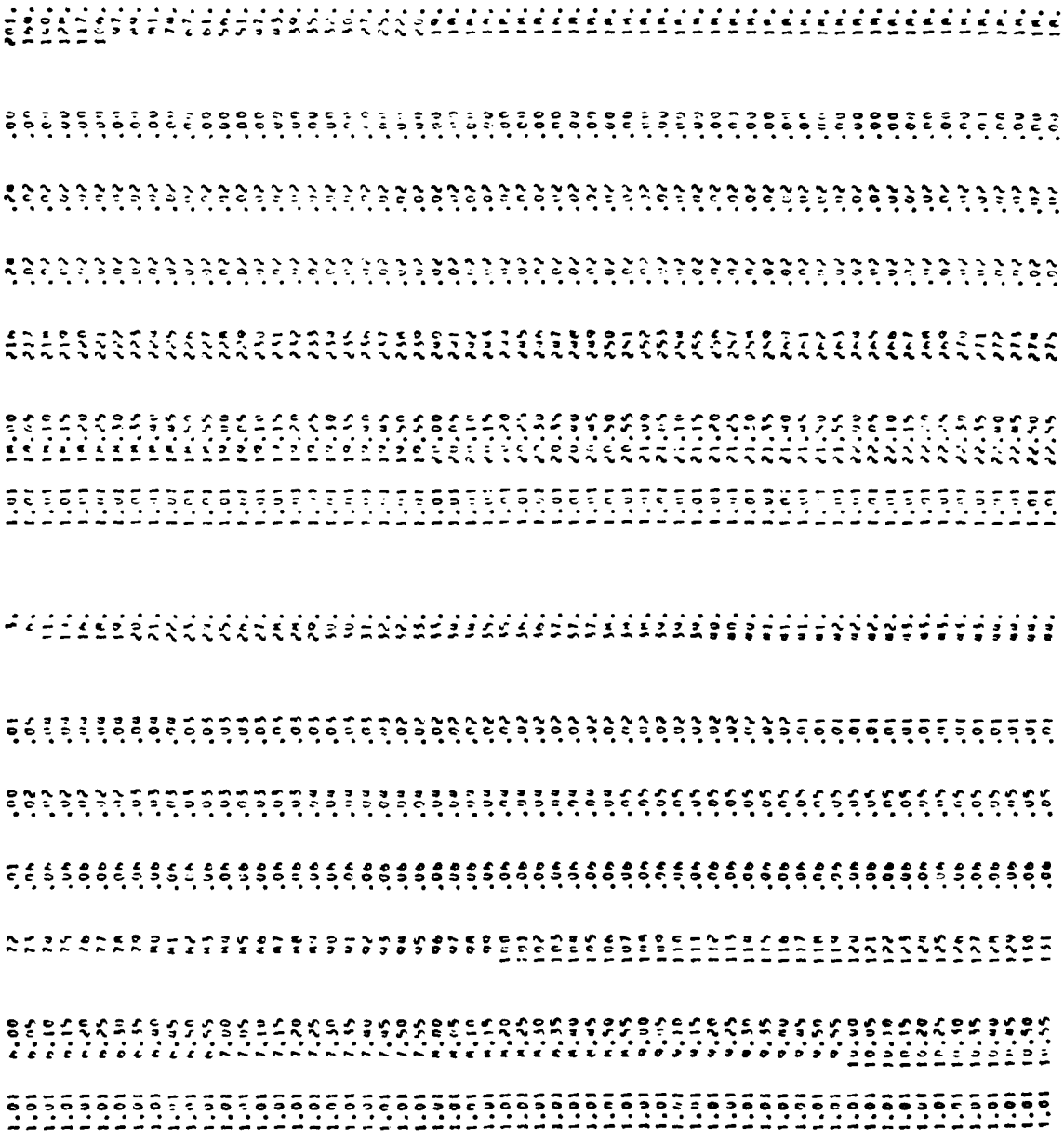
UNIT HYDROGRAPH 9 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .12 VOL= 1.00

175. 334. 199. 82. 35. 15. 6. 3. 1.

END-OF-PERIOD FLOW

0 MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	.00	.01	1.	1.01	12.05	145	.22	.19	.03	69.
1.01	.10	2	.01	.00	.01	2.	1.01	12.10	146	.22	.19	.03	110.
1.01	.15	3	.01	.00	.01	2.	1.01	12.15	147	.22	.19	.03	141.
1.01	.20	4	.01	.00	.01	2.	1.01	12.20	148	.22	.19	.03	152.
1.01	.25	5	.01	.00	.01	2.	1.01	12.25	149	.22	.19	.03	158.
1.01	.30	6	.01	.00	.01	2.	1.01	12.30	150	.22	.19	.02	161.
1.01	.35	7	.01	.00	.01	2.	1.01	12.35	151	.22	.19	.02	163.
1.01	.40	8	.01	.00	.01	2.	1.01	12.40	152	.22	.19	.02	164.
1.01	.45	9	.01	.00	.01	2.	1.01	12.45	153	.22	.20	.02	165.
1.01	.50	10	.01	.00	.01	2.	1.01	12.50	154	.22	.20	.02	166.
1.01	.55	11	.01	.00	.01	2.	1.01	12.55	155	.22	.20	.02	167.





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COMBINE HYDROGRAPHS

COMBINATION OF RUNOFF FROM THREE AREAS WITHIN THE BASIN

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2UP+LO	2	0	0	0	0	0	0	0

SUM OF 2 HYDROGRAPHS AT 2UP+LO PLAN 1 RTIO 6

1.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	4.	4.	4.	4.
4.	4.	4.	4.	4.	4.	4.	4.	4.	5.
5.	5.	5.	5.	5.	5.	6.	6.	6.	6.
6.	6.	7.	7.	7.	7.	7.	7.	8.	8.
8.	8.	11.	14.	20.	22.	24.	25.	28.	29.
31.	33.	34.	36.	38.	40.	41.	43.	45.	47.
49.	50.	52.	54.	56.	54.	60.	62.	64.	65.
67.	69.	71.	73.	75.	77.	79.	81.	83.	85.
87.	88.	90.	92.	94.	96.	98.	100.	102.	104.
105.	107.	109.	111.	113.	114.	120.	124.	124.	132.
136.	140.	145.	147.	151.	154.	158.	161.	165.	168.
171.	175.	174.	181.	207.	255.	286.	305.	314.	323.
332.	340.	354.	362.	379.	397.	422.	454.	481.	504.
524.	547.	567.	584.	604.	629.	650.	670.	702.	743.
776.	802.	825.	847.	868.	891.	928.	964.	1000.	1034.
1069.	1075.	1147.	1242.	1368.	1650.	2285.	2584.	2335.	2061.
1918.	1851.	1875.	1926.	2000.	2087.	2172.	2250.	2318.	2378.
2419.	2454.	2480.	2500.	2503.	2491.	2480.	2480.	2477.	2472.
2465.	2456.	2446.	2434.	2421.	2407.	2358.	2313.	2282.	2249.
2218.	2181.	2144.	2106.	2065.	2022.	1976.	1929.	1880.	1831.
1780.	1730.	1679.	1629.	1580.	1550.	1481.	1433.	1386.	1350.
1318.	1287.	1256.	1226.	1196.	1167.	1138.	1110.	1082.	1055.
1028.	1002.	977.	952.	927.	903.	880.	857.	835.	814.
793.	772.	752.	733.	714.	695.	677.	660.	643.	632.
623.	614.	605.	596.	588.	579.	571.	562.	554.	546.
538.	531.	523.	515.	508.	501.	494.	487.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2584.	1888.	650.	650.	187211.
CMS	73.	53.	18.	18.	5301.
INCHES		18.68	25.73	25.73	25.73
MM		474.52	653.58	653.58	653.58
AC-FT		936.	1289.	1289.	1289.
THOUS CU M		1155.	1590.	1590.	1590.

HYDROGRAPH ROUTING

SPILLWAY ROUTING, THREE WATERSHEDS THROUGH LOWER DAM

ISTAG	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
L LAKE	1	0	0	2	0	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	NSTPI	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-735.	-1

STAGE	733.00	734.10	734.70	736.00	737.50	738.60	738.90	739.50	740.50	741.00
FLOW	0.00	0.00	54.00	194.00	535.00	1450.00	1890.00	2820.00	3920.00	4020.00
SURFACE AREA=	0.	4.	7.	10.	13.	16.	20.	25.		
CAPACITY=	0.	23.	75.	152.	210.	285.	370.	486.		
ELEVATION=	700.	720.	735.	740.	745.	750.	755.	760.		

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
733.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
737.5	0.0	0.0	0.

STATION L LAKE, PLAN 1, RATIO 6

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	3.	3.	3.
3.	3.	4.	4.	4.	4.	5.	5.	5.	6.
6.	7.	9.	11.	15.	15.	18.	18.	20.	22.
24.	25.	27.	29.	31.	33.	35.	80.	80.	84.
52.	55.	59.	62.	65.	68.	71.	74.	77.	79.
82.	84.	87.	89.	91.	93.	96.	99.	101.	104.
107.	110.	113.	116.	120.	123.	126.	129.	133.	136.
139.	142.	146.	149.	153.	161.	172.	185.	197.	220.
241.	259.	276.	291.	306.	322.	338.	357.	378.	399.
421.	443.	464.	485.	506.	527.	564.	605.	639.	674.
710.	745.	773.	799.	820.	847.	873.	900.	936.	979.
1000.	1024.	1041.	1116.	1194.	1324.	1068.	2093.	2267.	2235.
2117.	2005.	1937.	1920.	1900.	1989.	2056.	2130.	2205.	2271.
2330.	2386.	2422.	2442.	2421.	2405.	2420.	2435.	2460.	2476.
2471.	2464.	2455.	2445.	2433.	2420.	2402.	2470.	2537.	2588.
2271.	2237.	2202.	2166.	2124.	2083.	2036.	2002.	1956.	1908.
1865.	1795.	1729.	1674.	1627.	1577.	1528.	1479.	1437.	1410.
1380.	1348.	1317.	1286.	1256.	1225.	1196.	1166.	1137.	1109.
1081.	1054.	1027.	1001.	976.	951.	926.	902.	879.	856.
834.	812.	791.	771.	751.	731.	712.	694.	676.	660.
644.	628.	614.	600.	585.	571.	557.	544.	530.	517.
504.	491.	467.	467.	455.	443.	432.	420.		

PEAK OUTFLOW IS 2495. AT TIME 17.17 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2495.	1887.	638.	638.	182718.
CMS	71.	53.	18.	18.	5174.
INCHES		18.87	25.11	25.11	25.11
MM		474.25	637.89	637.89	637.89
AC-FT		936.	1258.	1258.	1258.
THOUS CU M		1154.	1552.	1552.	1552.

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)

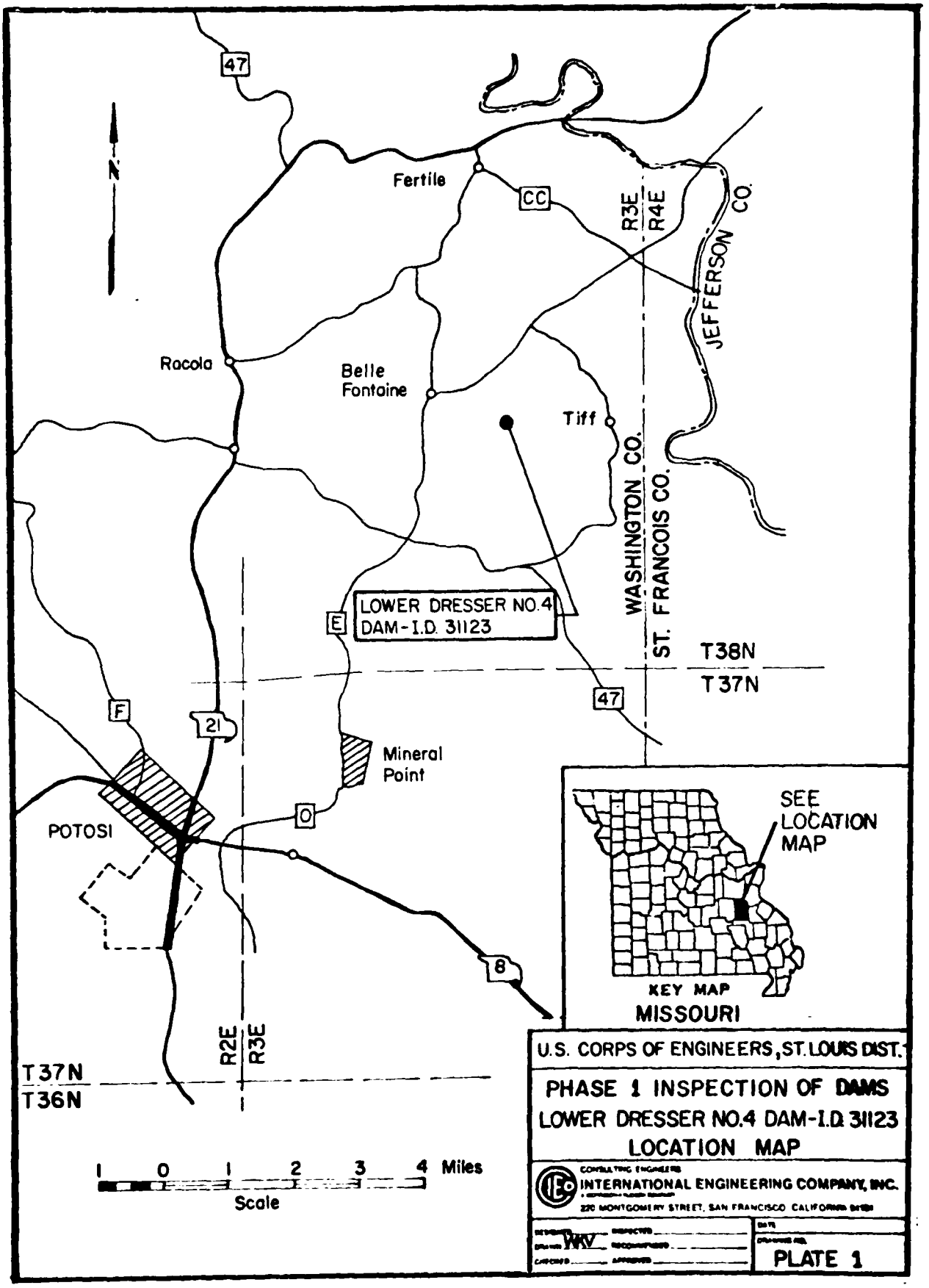
OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .10	RATIO 2 .25	RATIO 3 .50	RATIO 4 .65	RATIO 5 .80	RATIO 6 1.00
HYDROGRAPH AT	INFLOW	.71	1	822.	1955.	2111.	2708.	3378.	8222.
		(1.84)	(	11.96)(	29.89)(	59.78)(	77.71)(	95.68)(	119.55)(
HYDROGRAPH AT	INFLOW	.12	1	137.	383.	685.	891.	1096.	1371.
		(.31)	(	3.88)(	9.70)(	19.41)(	25.23)(	31.05)(	38.81)(
2 COMBINED	UPPER	.83	1	882.	1154.	2308.	3001.	3698.	8617.
		(2.15)	(	13.07)(	32.68)(	65.37)(	84.98)(	104.59)(	130.78)(
ROUTED TO	U LAKE	.83	1	126.	455.	1015.	1365.	1782.	2275.
		(2.15)	(	3.57)(	12.26)(	28.75)(	38.67)(	50.46)(	64.45)(
HYDROGRAPH AT	INFLOW	.11	1	151.	378.	755.	982.	1208.	1510.
		(.28)	(	4.28)(	10.69)(	21.38)(	27.80)(	34.21)(	42.77)(
2 COMBINED	UPPLO	.94	1	199.	580.	1197.	1572.	2010.	2588.
		(2.43)	(	5.64)(	15.28)(	33.90)(	44.50)(	56.92)(	73.18)(
ROUTED TO	L LAKE	.98	1	134.	475.	1118.	1496.	1947.	2495.
		(2.53)	(	3.79)(	13.46)(	31.56)(	42.36)(	55.13)(	70.66)(

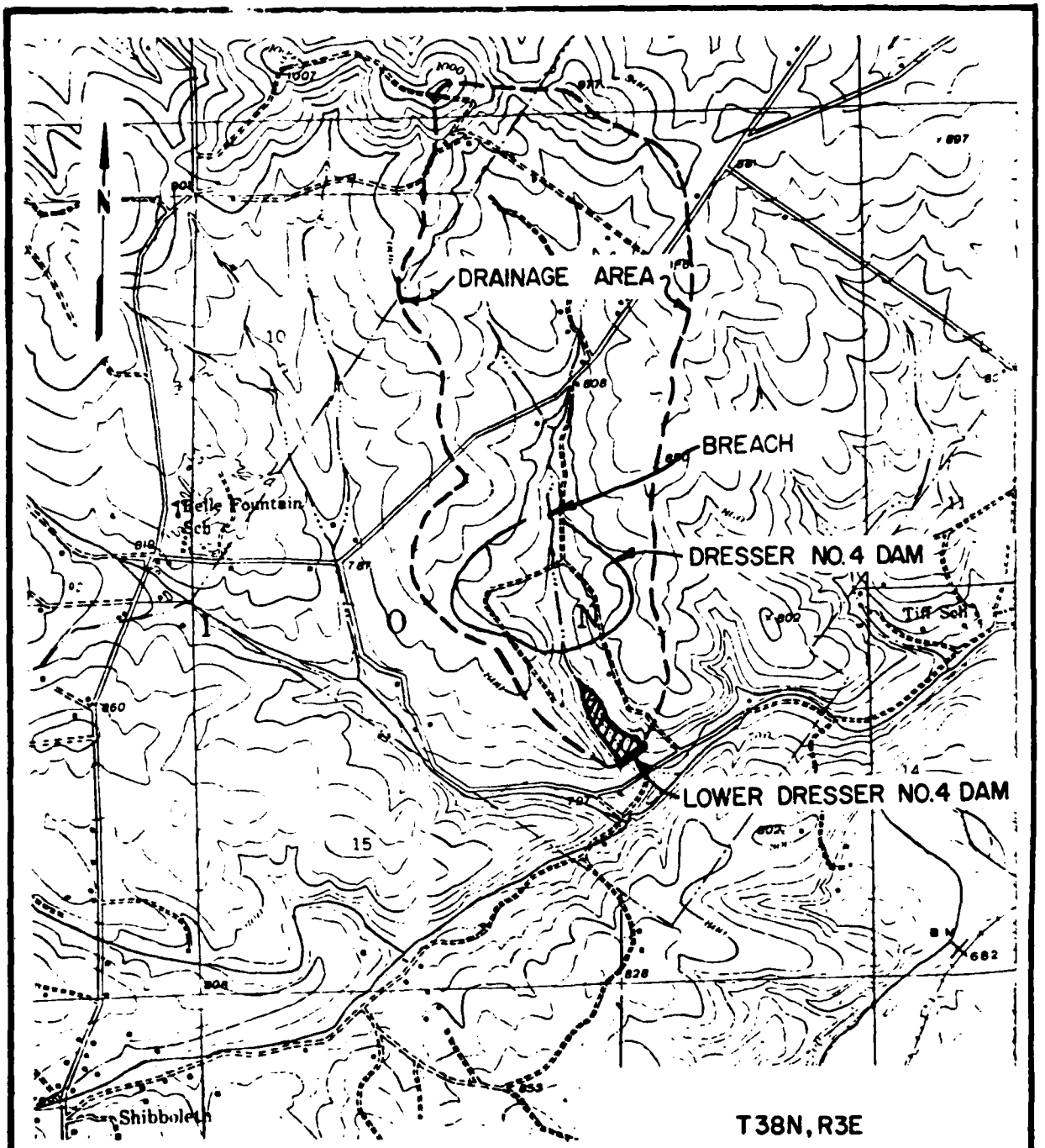
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	733.40	733.40	737.50
STORAGE	95.	95.	128.
OUTFLOW	0.	0.	676.

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
.10	735.51	0.00	111.	134.	0.00	18.67	0.00
.25	737.07	0.00	125.	475.	0.00	18.08	0.00
.50	738.12	.62	138.	1114.	4.50	17.75	0.00
.65	738.63	1.13	139.	1496.	5.67	17.58	0.00
.80	738.96	1.46	142.	1947.	7.00	17.25	0.00
1.00	739.55	2.05	148.	2695.	8.25	17.17	0.00


47
N
Fertile
CC
R3E
R4E
JEFFERSON CO.
Racola
Belle
Fontaine
Tiff
WASHINGTON CO.
ST. FRANCOIS CO.
LOWER DRESSER NO.4
DAM-I.D. 31123
E
T38N
T37N
47
F
21
Mineral
Point
O
POTOSI
8
R2E
R3E
T37N
T36N
1 0 1 2 3 4 Miles
Scale
SEE
LOCATION
MAP
KEY MAP
MISSOURI
U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.
PHASE 1 INSPECTION OF DAMS
LOWER DRESSER NO.4 DAM-I.D. 31123
LOCATION MAP
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET, SAN FRANCISCO CALIFORNIA
PLATE 1



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

PHASE I INSPECTION OF DAMS
LOWER DRESSER NO.4 DAM - I.D. 31123
VICINITY TOPOGRAPHY

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

DESIGNED ____ INSPECTED ____ DATE
DRAWN ____ RECOMMENDED ____ DRAWING NO.
CHECKED ____ APPROVED ____ PLATE 2

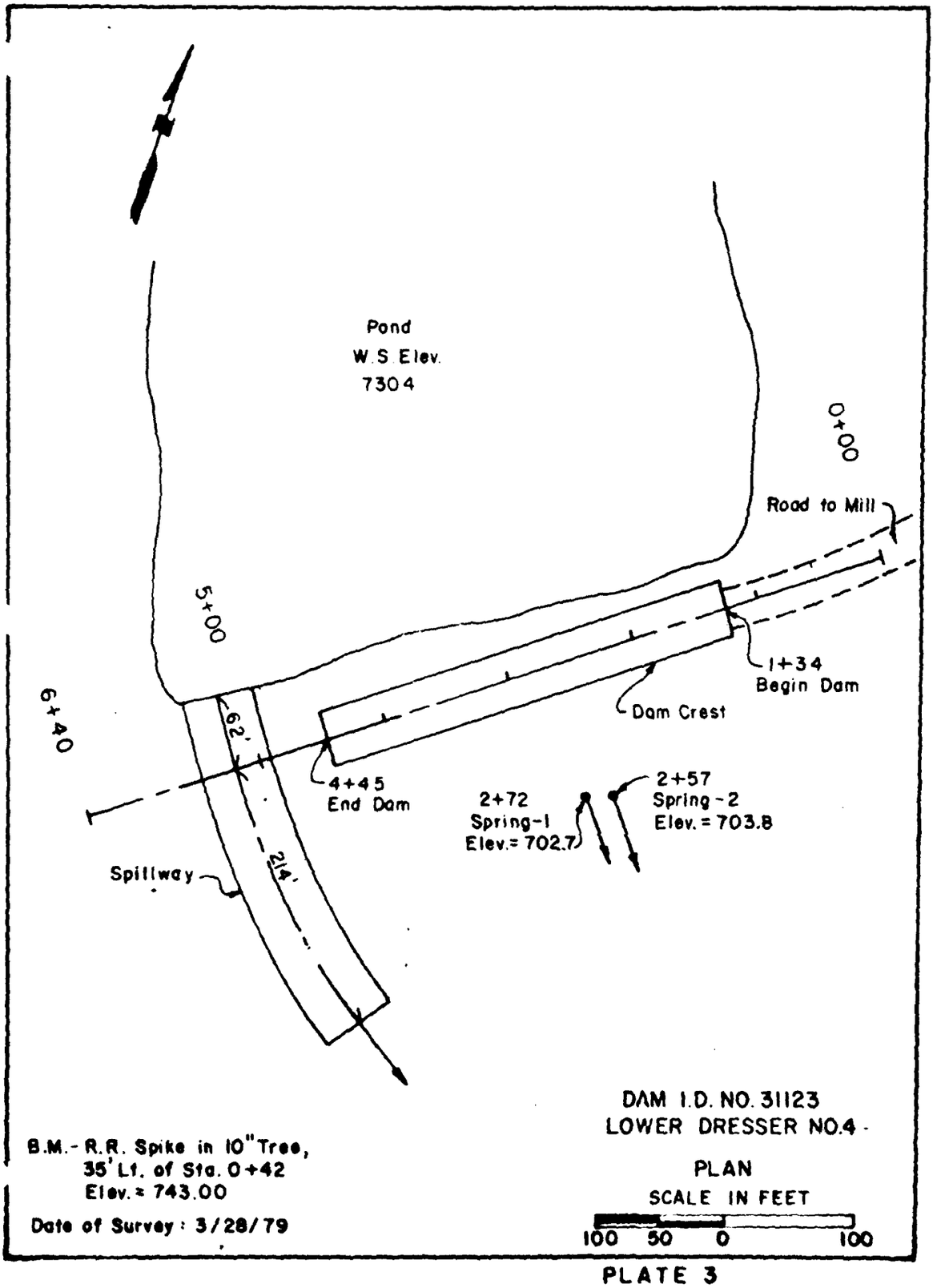
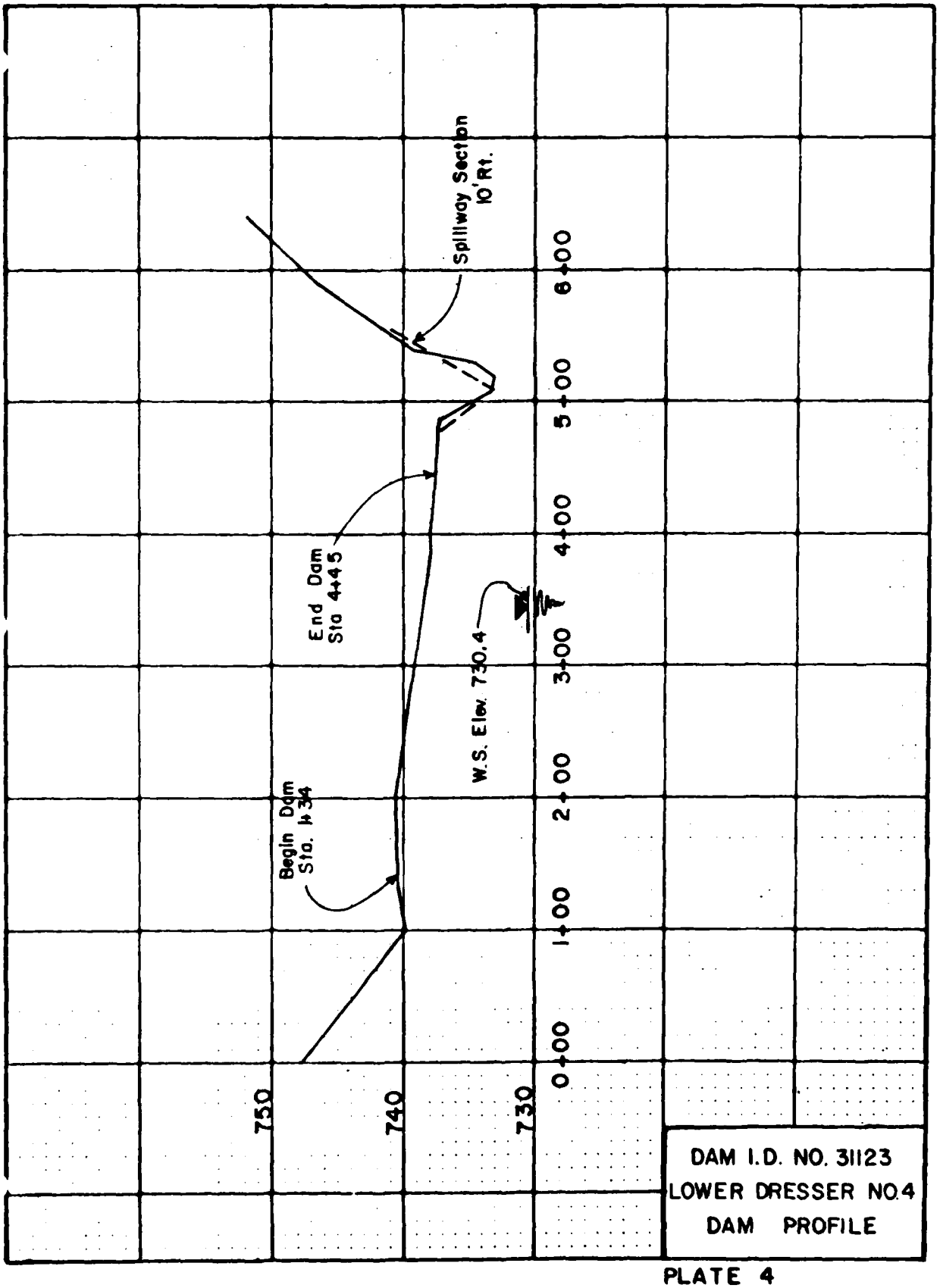

Pond
W.S Elev.
7304
0+00
Road to Mill
5+00
1+34
Begin Dam
Dam Crest
6+40
62'
4+45
End Dam
2+72
Spring-1
Elev.= 702.7
2+57
Spring-2
Elev. = 703.8
Spillway
214'
B.M.- R.R. Spike in 10" Tree,
35' Lt. of Sta. 0+42
Elev.= 743.00
Date of Survey: 3/28/79
DAM I.D. NO. 31123
LOWER DRESSER NO.4
PLAN
SCALE IN FEET
100 50 0 100

PLATE 3



DAM I.D. NO. 31123
LOWER DRESSER NO.4
DAM PROFILE

PLATE 4

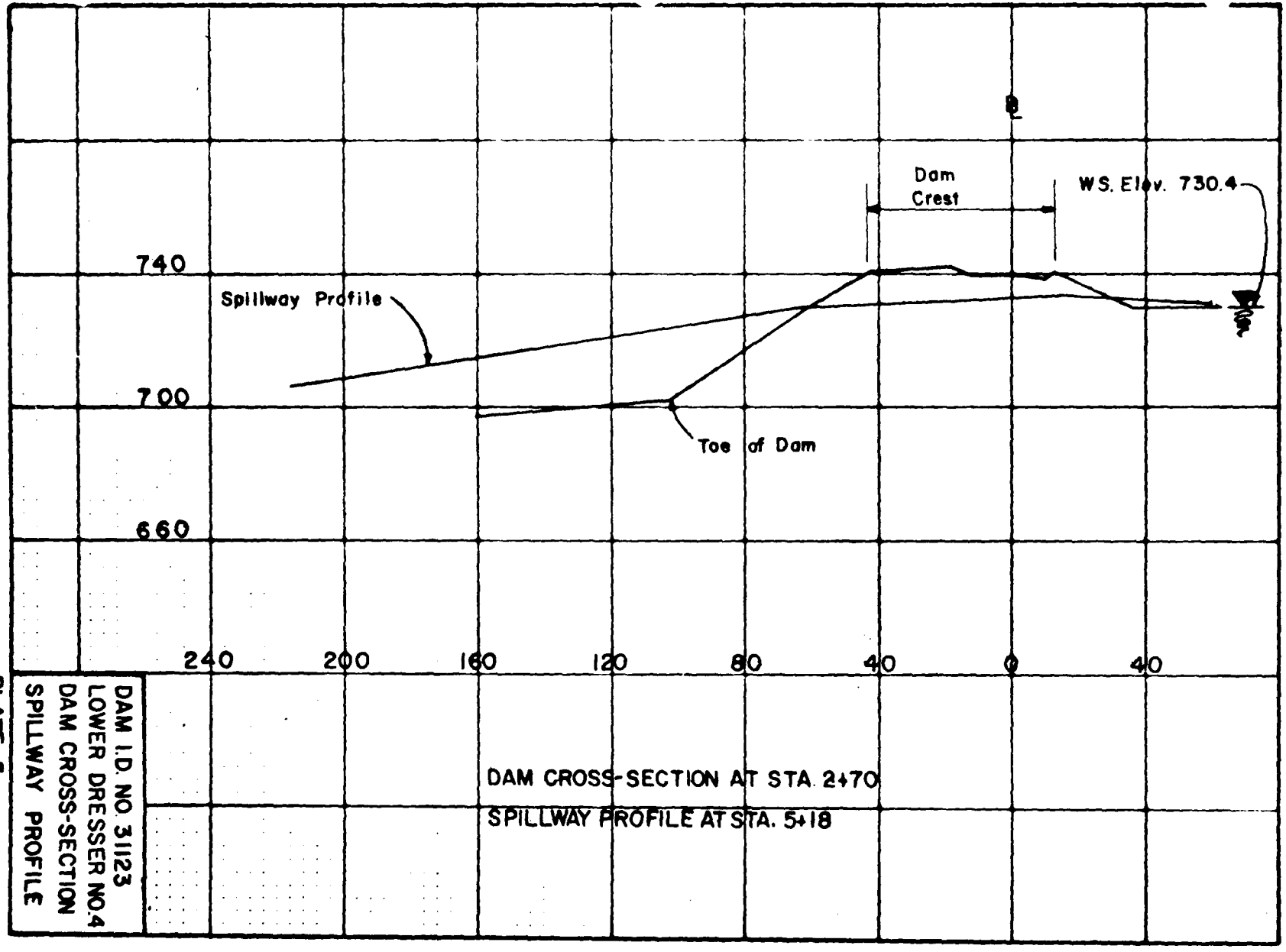
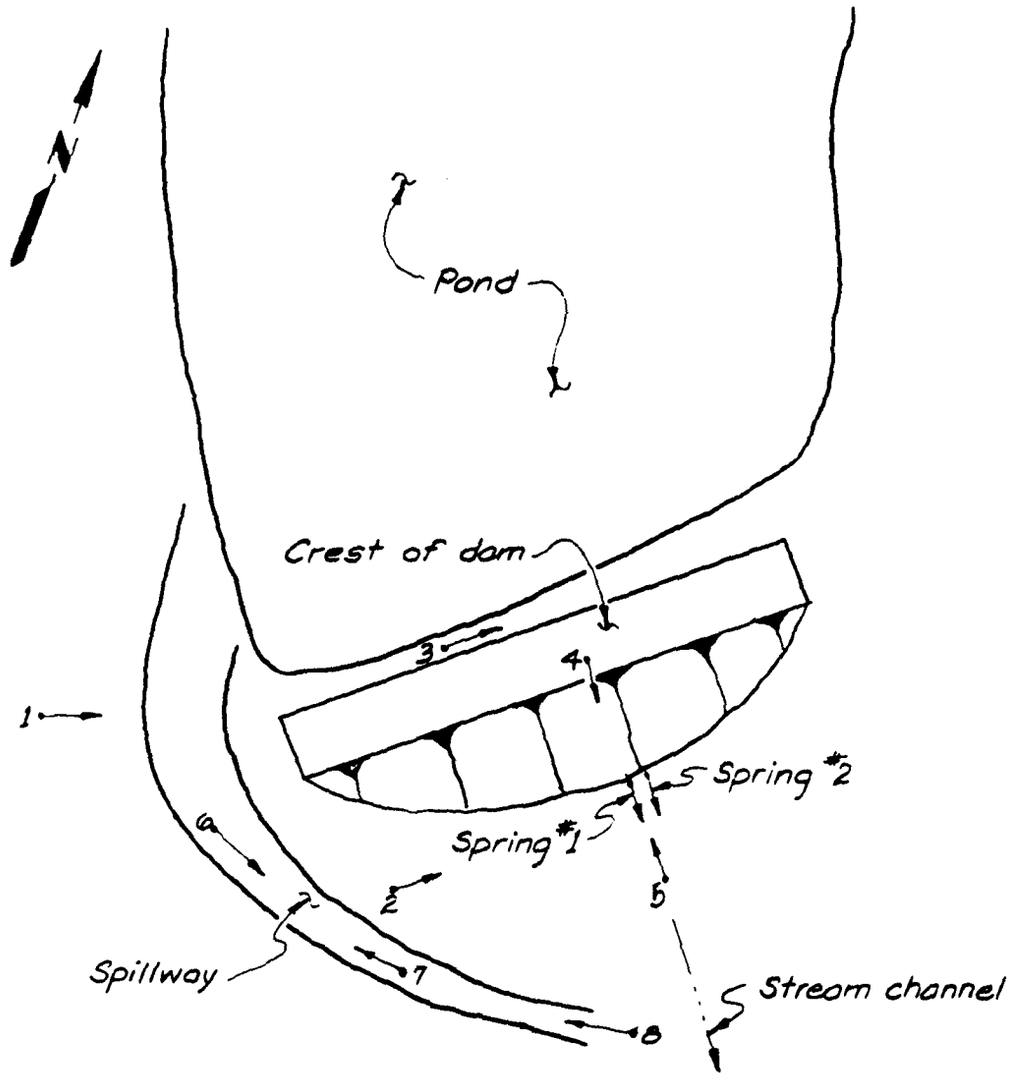


PLATE 5

DAM I.D. NO 31123
LOWER DRESSER NO.4
DAM CROSS-SECTION
SPILLWAY PROFILE



Not to scale

LEGEND:
4 → Photo number and view direction.

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

PHASE I INSPECTION OF DAMS
LOWER DRESSER NO. 4 DAM I.D. 31123
PHOTOGRAPH LOCATION MAP

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

PLATE 6

PHOTOGRAPH RECORD

LOWER DRESSER NO. 4 DAM - I.D. NO. 31123

Photo No.	Description
1.	View of dam and pond from right abutment. The spillway channel is in foreground, between the survey laths and vehicles.
2.	Downstream face of dam from right abutment.
3.	Upstream face of dam towards left abutment. Scarp and beach were caused by wave erosion.
4.	Two springs at toe of dam. Spring No. 1 is at the right side of photograph and Spring No. 2 is on the left side.
5.	Spring No. 1 at toe of dam.
6.	View downstream in spillway. The channel narrows in the downstream direction.
7.	View upstream in spillway channel showing condition of bedrock.
8.	Downstream end of spillway channel.

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