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BLACK AND VEATCH KANSAS CITY MO
NATIONAL DAM SAFETY PROGRAM. HOLY'S LAKE DAM (NO 11105), MISSOURI--ETC(U)
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MISSOURI-KANSAS CITY DAM

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HOLT'S LAKE DAM

ST. LOUIS COUNTY, MISSOURI

RD 11105

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**PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM**

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**United States Army
Corps of Engineers
Engineering Division**

St. Louis District

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

FOR: STATE OF MISSOURI

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MISSOURI-KANSAS CITY BASIN

HOLT'S LAKE DAM
ST. LOUIS COUNTY, MISSOURI
MO 11105

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PHASE 1 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

NOVEMBER 1980



REPORT TO
ATTENTION OF

DEPARTMENT OF THE ARMY

ST. LOUIS DISTRICT, CORPS OF ENGINEERS

210 TUCKER BOULEVARD, NORTH

ST. LOUIS, MISSOURI 63101

SUBJECT: Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Holt's Lake Dam (MO 11105).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

- a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.
- b. Overtopping of the dam could result in failure of the dam.
- c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY:

SIGNED

Chief, Engineering Division

7 MAY 1981

Date

APPROVED BY :

SIGNED

Colonel, CE, District Engineer

11 MAY 1981

Date

HOLT'S LAKE DAM
ST. LOUIS COUNTY, MISSOURI
MISSOURI INVENTORY NO. 11105

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:
BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

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

NOVEMBER 1980

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Holt's Lake Dam
State Located	Missouri
County Located	St. Louis County
Stream	Tributary to Caulks Creek
Date of Inspection	18 November 1980

Holt's Lake Dam was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as an intermediate size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers, failure would threaten lives and property. The estimated damage zone extends approximately two miles downstream of the dam. Within the estimated damage zone are four dwellings, a railroad, and a highway (CC). Contents of the estimated downstream damage zone were verified by the inspection team.

Our inspection and evaluation indicates the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will not pass the probable maximum flood without overtopping but will pass 15 percent of the probable maximum flood. The spillway will pass the flood which has a one percent chance of occurrence in any given year (100-year flood). The spillway design flood recommended by the guidelines is 100 percent of the probable maximum flood. The probable maximum flood is defined as the flood discharge which may be expected from the most severe combination of critical meteorologic and hydrologic conditions which are reasonably possible in the region.

Based on visual observations, this dam appears to be in satisfactory condition. Deficiencies visually observed by the inspection team were erosion on the downstream left and right interfaces between the embankment and abutments, erosion on the upstream right embankment-abutment interface, and an upslope road cut on upstream face which is

beginning to slough. Other deficiencies observed include trees on both slopes of the embankment, animal burrows on both slopes, erosion in the area of the spillway's inlet and outlet, and an eroded ditch near the toe of the dam. Seepage and stability analyses required by the guidelines were not available.

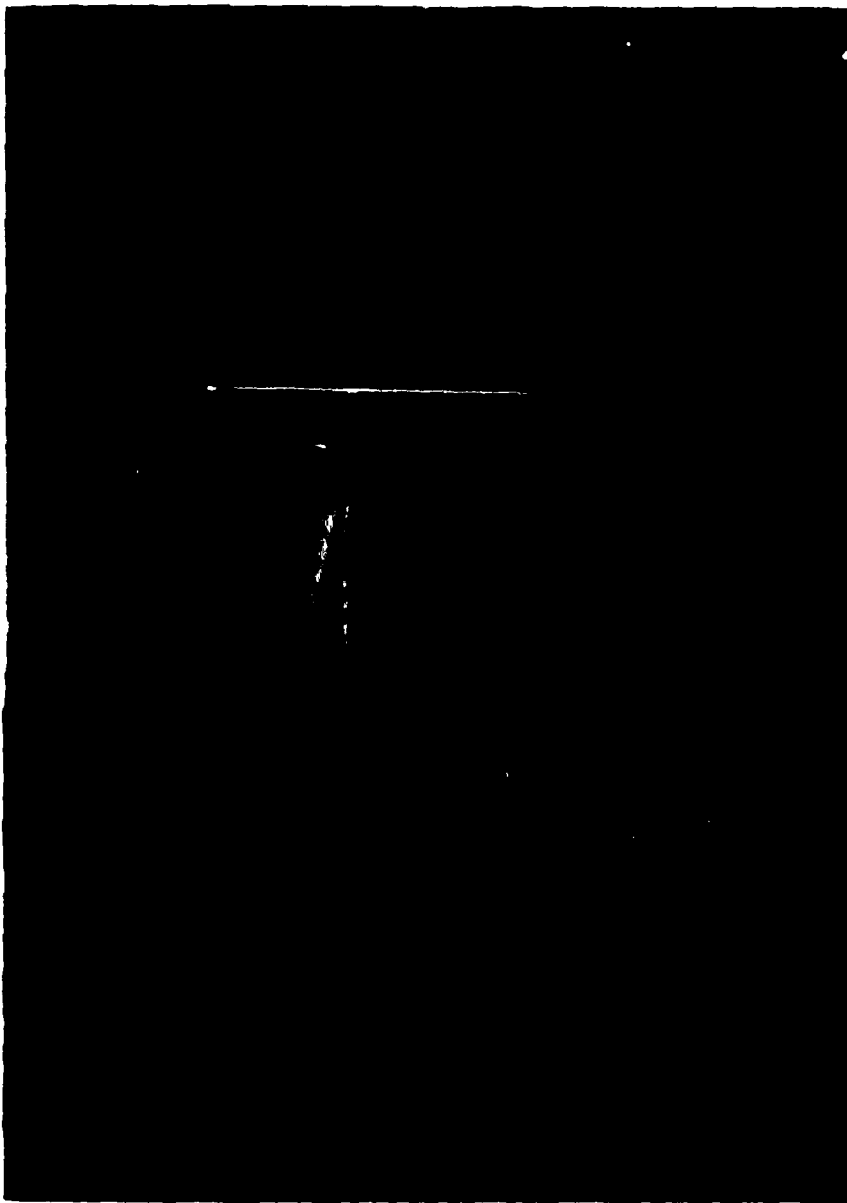
There were no observed deficiencies or conditions existing at the time of the inspection which indicated an immediate safety hazard. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. In addition, detailed seepage and stability analyses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

Edwin R. Burton

Edwin R. Burton, PE
Missouri E-10137

Harry L. Callahan

Harry L. Callahan, Partner
Black & Veatch



OVERVIEW OF DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
HOLT'S LAKE DAM

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Appendix A - Hydrologic and Hydraulic Analyses

Appendix B - Grouting Operations

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

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

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

1. The dam is an earth structure located in the valley of a tributary of Caulks Creek (see Plate 1). The watershed is an area of low hills with relatively steep slopes consisting of about 10 percent urban development and 90 percent wooded land. The dam is approximately 50 feet long along the crest and 47 feet high. The dam crest is about 7 feet wide. A 20-foot wide asphaltic pavement road is located along the crest of the dam. The upstream slope of the embankment varies from 1.7 to 4.0 feet horizontal to 1-foot vertical. The downstream slope ranges from 1.8 to 2.9 feet horizontal to 1-foot vertical.

2. The spillway is a 30-inch diameter corrugated metal pipe which is reported to have concrete collars. The spillway is located near the left end of the dam and discharges to a concrete chute on the downstream slope of the dam. Left and right are used herein to define direction while facing downstream. The flow from the chute is directed to an unlined ditch and is uncontrolled.

Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in westcentral St. Louis County, Missouri, as indicated on Plate 1. The lake formed by the dam is shown on the United States Geological Survey 7.5 minute series quadrangle map for Chesterfield, Missouri, in Section 17 of T45N, R04E.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the intermediate size category. An intermediate size dam is classified as having a height less than 100 feet, but greater than or equal to 40 feet and/or a storage capacity less than 50,000 acre-feet, but greater than or equal to 1,000 acre-feet.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: Holt's Lake Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For Holt's Lake Dam the estimated flood damage zone extends approximately two miles downstream of the dam. Within the estimated damage zone are four dwellings, a railroad, and one highway (CC). Contents of the estimated downstream damage zone were verified by the inspection team.

e. Ownership. The dam is owned by the Chesterfield Lakes Homeowner's Association, % Mr. William Roberts, 1516 Chesterfield, Chesterfield, Mo. 63017.

f. Purpose of Dam. The dam will form a 14.5-acre lake used for recreation.

g. Design and Construction History. Data relating to the design and construction were not available. According to the developer, Burton-Duenke Construction Company, the dam was constructed in 1973.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, evaporation, and overflow through the uncontrolled spillway would all combine to maintain a relatively stable water surface elevation. The reservoir pool has not reached the spillway elevation since completion of the dam.

1.3 PERTINENT DATA

a. Drainage Area - 259 acres

b. Discharge at Damsite.

11. Discharge at the damsite is through a 30-inch diameter corrugated metal pipe.

12. Estimated experienced maximum flood at damsite - Unknown.

13. Estimated ungated spillway capacity at maximum pool elevation 54 cfs (Probable Maximum Flood Pool El. 538.4).

14. Elevation (feet above m.s.l.) Approximate Tie to USGS Map:

1. Top of dam - 535.8 (see Plate 3)

2. Spillway invert - 530.0

3. Streambed at toe of dam - 489.0

4. Maximum tailwater - Unknown.

15. Reservoir:

1. Length of maximum pool - 2,450 feet * Probable maximum flood pool level

2. Length of normal pool - 2,000 feet * Spillway invert

16. Storage - Acre-feet

1. Top of dam - 54

2. Spillway invert - 520

Design surcharge - Not available.

17. Reservoir Surface - Acres

1. Top of dam - 54

2. Spillway invert - 54

18. Dam:

1. Type - Earth embankment

2. Length - 450 feet

3. Height - 47 feet *

d. Top width - 7.2 feet (crowned)
e. Side slopes - upstream face between 1.0 V on 2.7 H and 1.0 V on 4.0 H; downstream face between 1.0 V on 3.8 H and 1.0 V on 7.9 H (see Plate 4)

- f. Lining - Unknown
- g. Impervious core - Unknown
- h. Cut-off - Unknown
- i. Grout curtain - Unknown
- j. Diversion and Regulating Tunnel - None

Spillway

- a. Type - 60-inch diameter corrugated metal pipe
- b. Inlet invert elevation - 530.0 feet m.s.l.
- c. Outlet invert elevation - 528.2 feet m.s.l.
- d. Gates - None
- e. Upstream channel - None
- f. Downstream channel - Discharges to a concrete chute and then to an earthen ditch at the dam's toe

Emergency Spillway - None

- g. Regulating Outlets - None

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

The dam was designed by the firm of Volz Engineering and Surveying, Inc. They provided hydrologic and hydraulic calculations for the spillway, a contour map of the dam and reservoir site, and a report on grouting operations.

2.2 CONSTRUCTION

Construction records were unavailable. According to the developer, Burton-Duenke Construction Co., the dam was constructed in 1973.

2.3 OPERATION

Operational records and documentation of past floods were unavailable.

2.4 GEOLOGY

The site of the dam and reservoir is located in a moderately-deep steep-sided valley between two ridges. The dam impounds a small, intermittent, tributary of Caulk's Creek.

Published information was not available on the soils in the area of the dam and reservoir. The bedrock consists of limestone of the Burlington formation of the Osage Series of the Mississippian System. According to the letter in Appendix B, the reservoir is seeping through a zone of weakness that extends beneath the reservoir parallel and upstream of the dam. The seepage travels through a horizontal feeder system and exits at a spring located at Caulk's Creek. The Contractor has attempted to grout these horizontal feeders, and the grouting has apparently decreased the seepage. Additional grouting may be done if seepage quantities increase after the reservoir is filled. Since the seepage is through the bedrock, it should not present a hazard to the embankment.

2.5 EVALUATION

4. Availability. Some engineering data were available. Representatives of both the design engineer and construction company were present during the inspection and answered questions.

1. Adequacy. Engineering data available included hydrologic and hydraulic calculations for the spillway, and storage-elevation curves. The hydrologic and hydraulic design does not meet the criteria established by the guidelines. No embankment design or construction data were available, thus an assessment of the embankment design, construction, and operation

could not be made. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity. The spillway is designed to pass a 100-year 30-minute flood from a fully developed watershed. The design is valid but does not meet the requirements of the Guidelines. The validity of the embankment design, construction, and operation could not be determined due to the lack of engineering data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General A visual inspection of Holt's Lake Dam was made on 18 November 1980. The inspection team consisted of Edwin Burton, team leader, Robert Pinker, geologist, Gary Van Riessen, geotechnical engineer, and John Ruhl, hydraulic/hydrologic engineer. Messrs. J. Davies and J. Lasky representing the Burton-Duenke Construction Company, and Mr. G. Borgard representing Volz Engineering and Surveying, Inc., accompanied the inspection team. The dam appeared to be in satisfactory condition. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam The inspection team observed the following conditions at the dam. No cracking, sliding, sloughing or other signs of settlement or instability were observed except at the gravel road down the upstream embankment slope. The upstream and downstream slopes of the embankment have some tree cover. No instruments to measure the performance of the dam were located. No toe drains or relief wells were observed although there is a ditch below the dam's toe which could serve as a drain.

The dam crest has a 22-foot wide asphaltic pavement road along its entire length which is broken in places. This damage is believed to be either the result of poor or the lack of adequate subgrade material.

There is a road cut down the upstream embankment slope. This road was built to accommodate access to the pool area for grouting work. The road cut shows signs of sloughing. Some cracking was observed at this cut.

Some erosion gullies were observed around the inlet and outlet of the spillway pipe. Erosion has also occurred on the upstream face at the right abutment-embankment interface below the outlet of the drain pipe under Holt's Lake Drive.

No evidence was found to indicate that the embankment had ever been overtopped. The reservoir has never been filled due to leakage through geologic faults in the pool area.

There was evidence that a maintenance program was in effect. A few animal burrows were observed on the embankment.

c. Appurtenant Structures The inspection team observed the following items pertaining to the appurtenant structures. The spillway is a 30-inch corrugated metal pipe located near the left end of the dam.

There was erosion around the spillway inlet and outlet. The spillway pipe was considered to be in good condition. There is a slight deformation of the pipe and a slight dog leg alignment near the outlet. It should be noted that an abnormally large spillway discharge would probably damage the downstream slope.

There was no development in the spillway area which would suffer damage due to flow through the spillway.

d. Geology. The soils along the ridges and slopes of the reservoir are developed in loess and in residuum from the limestone bedrock. The loess is light brown in color and consists of silt and clay. For engineering purposes it is classified visually as a clayey silt of low plasticity. The residuum is dark reddish brown in color and consists of silt clay and chert fragments. For engineering purposes the soils are classified visually as silty clay of low plasticity with chert fragments. Soils developed in colluvium are present in the downstream valley. These soils are dark brown in color and consist of silt and clay. For engineering purposes the soils are classified visually as silty clay and clayey silt of low plasticity. No outcrops of bedrock were observed. Appendix B indicates rock is present near the bottom of the reservoir, and the existence of ridges indicates rock is present beneath them. The thickness of the overburden on the hills and in the valley is not known. No construction drawings or boring data were available. Evidence of grouting operations were observed along the left side of the hill and the shore of the reservoir.

Samples of the embankment material were taken near the center of the downstream crest using an Oakfield sampler. The soil samples were classified visually. Based on these samples, it is anticipated the embankment consists of clayey silt of low plasticity. The Contractor stated the core consists of clay.

e. Reservoir Area. No slumping or slides of the reservoir banks were observed. The upstream channel to the lake contains some minor debris and a few trees. The lake was noted to be clean with no siltation.

f. Downstream Channel. The spillway discharges to a concrete chute and then to an unlined ditch. The unlined ditch discharges to the natural channel downstream from the dam.

5.2 EVALUATION

The various deficiencies observed at the time of the inspection are not believed to represent an immediate safety hazard. They do, however, warrant monitoring and control.

The growth of trees if allowed to go unchecked, could cause deterioration of the embankment. The roots of trees can loosen the embankment material and also can leave voids through which water can pass.

Burrowing animals will continue to damage the embankment if a control program is not undertaken. Piping failure of embankments has resulted from damages caused by burrowing animals.

A gravel road starting at about station 2 + 90 on the crest and proceeding laterally to about station 3 + 90 before cutting into the upstream embankment slope has been a contributing factor to erosion. Upon completion of the grouting work in the reservoir pool area, this road cut should be restored to designed conditions. Gravel, debris, etc. found in this area should be removed before the cut is backfilled and compacted.

The road pavement on the crest should be repaired in those areas where it has broken.

No seepage problems were observed at this dam. However, problems have occurred with leakage from the reservoir pool through geologic faults. Close monitoring of the embankment should be maintained during the reservoir filling process following sealing by grout of geologic faults.

The absence of riprap on the upstream slope has not led to any problems because of the lack of an appreciable reservoir pool. Riprap protection should be provided to reduce the potential for wave induced erosion.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool level will be primarily controlled by rainfall, runoff, evaporation, transpiration, and capacity of the uncontrolled spillway once the lake is filled.

4.2 MAINTENANCE OF DAM

There was evidence that a maintenance program was in effect at the time of inspection. The grass cover along the crest has been mowed. Trees, however, were observed growing on the embankment.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no existing warning system or preplanned scheme for alerting downstream residents for this dam.

4.5 EVALUATION

The maintenance program should be continued and should include in addition to mowing the grass cover on the embankment a task for replacing broken pavement along the crest. Procedures for controlling tree growth should be formulated with the assistance of an engineer experienced in earthen dam maintenance.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Limited design data were made available. Included were hydraulic calculations for the 30-inch spillway pipe and storage-elevation curves.

b. Experience Data. The drainage area and lake surface area are developed from USGS Chesterfield, Mo. quadrangle map. The dam layout is from a survey made during the inspection and a plat map provided by the engineer.

c. Visual Observations.

(1) The spillway appears to be in good condition. The lake level at the time of the inspection (El. 507.6) was below the spillway pipe inlet. There were no obstructions to flow in the downstream channel.

(2) Spillway discharges could endanger the integrity of the dam.

d. Overtopping Potential. The spillway will not pass the probable maximum flood without overtopping the dam. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillway will pass 15 percent of the probable maximum flood without overtopping the dam. The spillway will pass the one percent chance flood estimated to have a peak outflow of 40 cfs developed from a 48-hour, one percent chance rainfall. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of intermediate size should pass 100 percent of the probable maximum flood. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 2,230 cfs of the total discharge from the reservoir of 2,290 cfs. The estimated duration of overtopping is 12.0 hours with a maximum height of 2.6 feet. The portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 1,050 cfs of a total discharge of 1,100 cfs. The estimated duration of overtopping is 9.0 hours with a maximum height of 1.8 feet. The embankment could be jeopardized should overtopping occur for these periods of time.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately two miles downstream of the dam. Four dwellings, a railroad, and a highway (CC) are located within the estimated damage zone, and lives could be lost should failure of the dam occur. Contents of the estimated downstream damage zone were verified by the inspection team. Flood plain regulations under the

National Flood Insurance Program restrict development in the flood plain
of Caulks Creek which is downstream of Holt's Lake Dam.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

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

b. Design and Construction Data. No design data relating to the structural stability of the dam were found. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Operating Records. No operational records exist.

d. Postconstruction Changes. It is not known whether or not any changes have been made to the dam subsequent to its construction. There is an ongoing grouting program in the reservoir pool area.

e. Seismic Stability. The dam is located in Seismic Zone 2 which is a zone of moderate seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservatism should pose no serious stability problems during earthquakes in this zone. The seismic stability of an earth dam is dependent upon a number of factors: embankment and foundation material classifications and shear strengths; abutment materials, conditions, and strengths; embankment zoning; and embankment geometry. Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the stability analysis required by the guidelines.

SECTION 7. ASSESSMENT REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several conditions observed during the visual inspection by the inspection team should be monitored and/or controlled. These are erosion on the downstream left and right interfaces between the embankment and abutments, erosion on the upstream right embankment-abutment interface, an upslope road cut on upstream face which is beginning to slough, trees on both slopes, animal burrows, erosion in the area of the spillway's inlet and outlet and erosion in a ditch near the toe of the dam. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

b. Adequacy of Information. Due to the absence of engineering design data, the conclusions in this report were based only on performance history, visual conditions and general information obtained during the inspection from the developer. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. It is the opinion of the inspection team that a program should be developed as soon as possible to implement remedial measures recommended in paragraph 7.2b. If the safety deficiencies listed in paragraph 7.1a are not corrected, they will continue to deteriorate and lead to a serious potential of failure. The item recommended in paragraph 7.2a should be pursued on a high priority basis.

d. Necessity for Phase II. The Phase I investigation does not raise any serious questions relating to the safety of the dam nor does it identify any serious dangers which would require a Phase II investigation. However, the additional analyses noted in paragraph 2.5b are necessary for compliance with the guidelines.

e. Seismic Stability. This dam is located in Seismic Zone 2. Adequate description of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the recommended stability analysis.

REMEDIAL MEASURES

a. Alternatives. Spillway capacity and/or storage volume would need to be increased or the lake level would need to be permanently lowered to increase available flood storage in order to effectively pass the spillway design flood. Spillway capacity could be increased by providing an emergency spillway. The storage volume could be increased by raising the dam crest.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures are recommended and should be carried out under the direction of a professional engineer experienced in the design, construction, and maintenance of earth dams.

(1) Erosion protection should be placed on the upstream face of the dam to an elevation above normal lake level to prevent erosion of the embankment material. Paved ditches or other slope protection may be required to control the concentrated runoff at the abutment-embankment interface. The erosion around the inlet and outlet of the spillway pipe should be repaired and adequate protection provided.

(2) A maintenance program should be formulated and implemented to remove and control the growth of trees on the embankment. Grass/ weed cover on the embankments should be cut periodically.

(3) The road cut on the upstream slope should be backfilled with suitable material and compacted upon completion of the grouting program.

(4) The animal burrows in the embankment should be corrected since they can contribute to the occurrence of piping. Control measures should be implemented to discourage animal activity in the area. The embankment slope should be monitored by a qualified engineer during repair of the embankment.

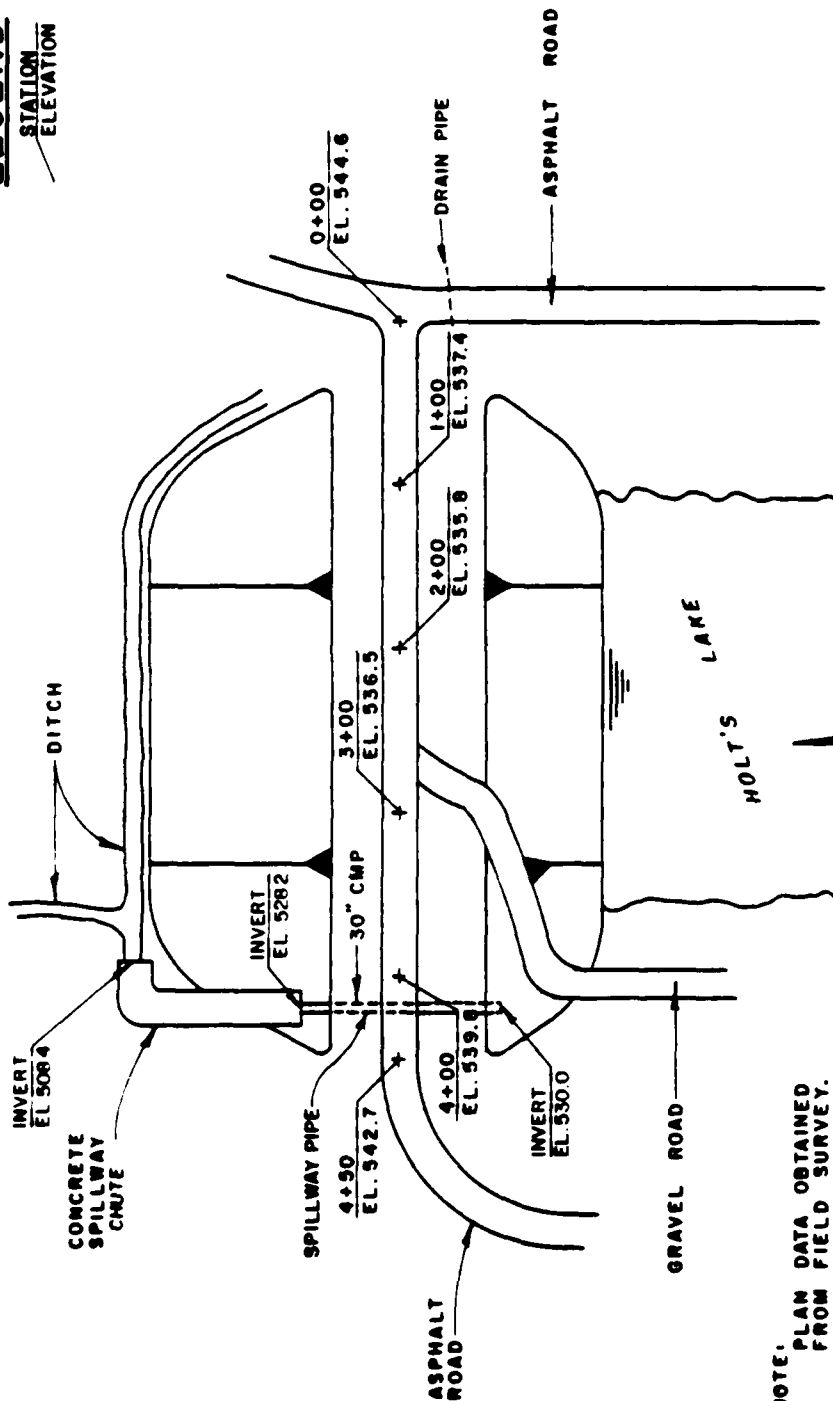
(5) Seepage and stability analyses should be performed.

(6) A detailed inspection of the dam should be made periodically and findings of the inspections should be documented and made a matter of record. More frequent inspections should be performed during the reservoir filling process to ascertain that leakage, seepage, slope instability, etc. do not occur undetected. If these types of problems occur, an engineer experienced in earth dams should be engaged to assist in formulating corrective measures.

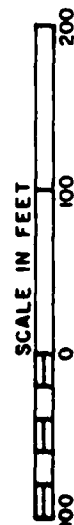


PLATE 2

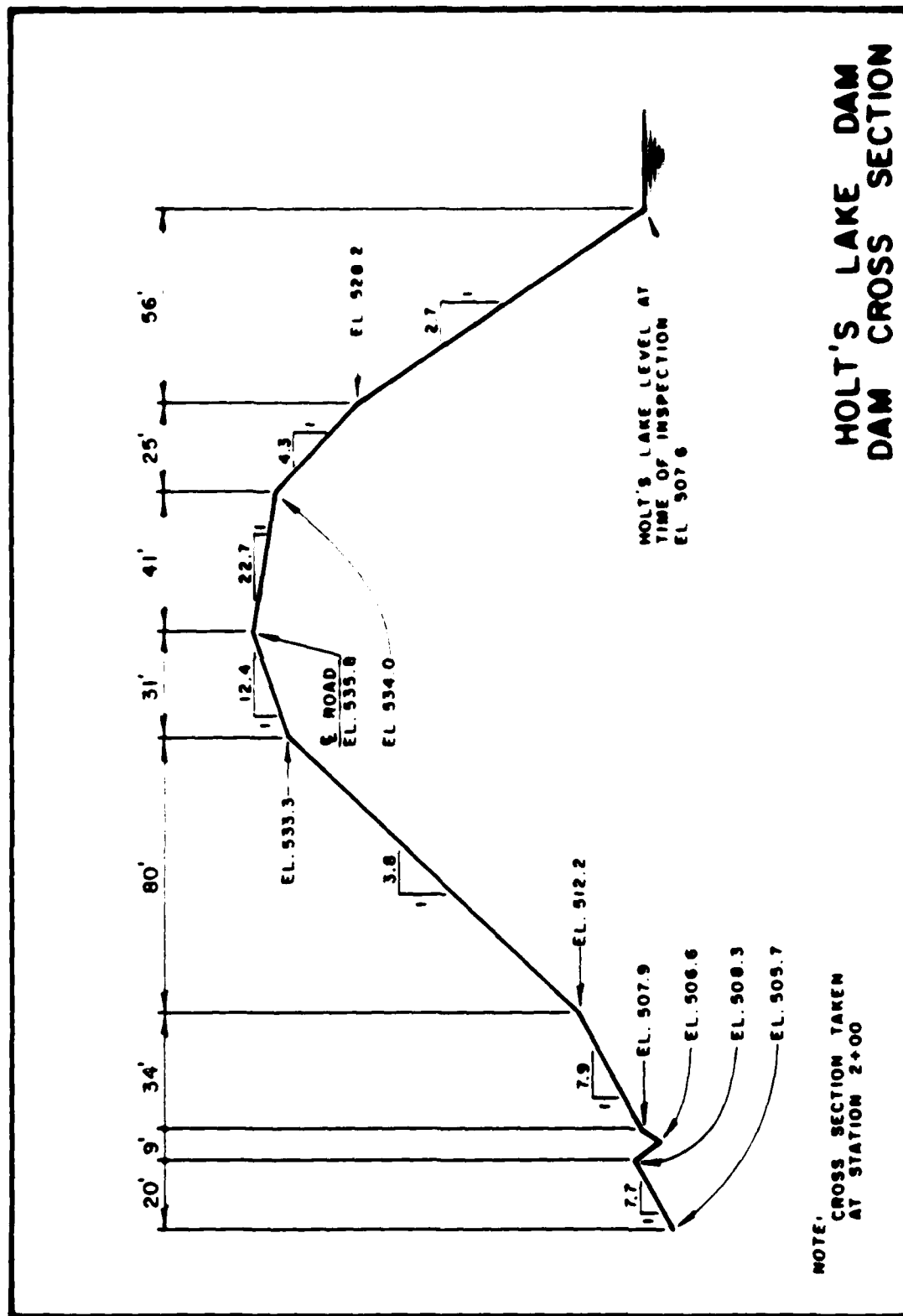
LEGEND
STATION
ELEVATION



NOTE:
PLAN DATA OBTAINED
FROM FIELD SURVEY.



**HOLT'S LAKE DAM
DAM PLAN**



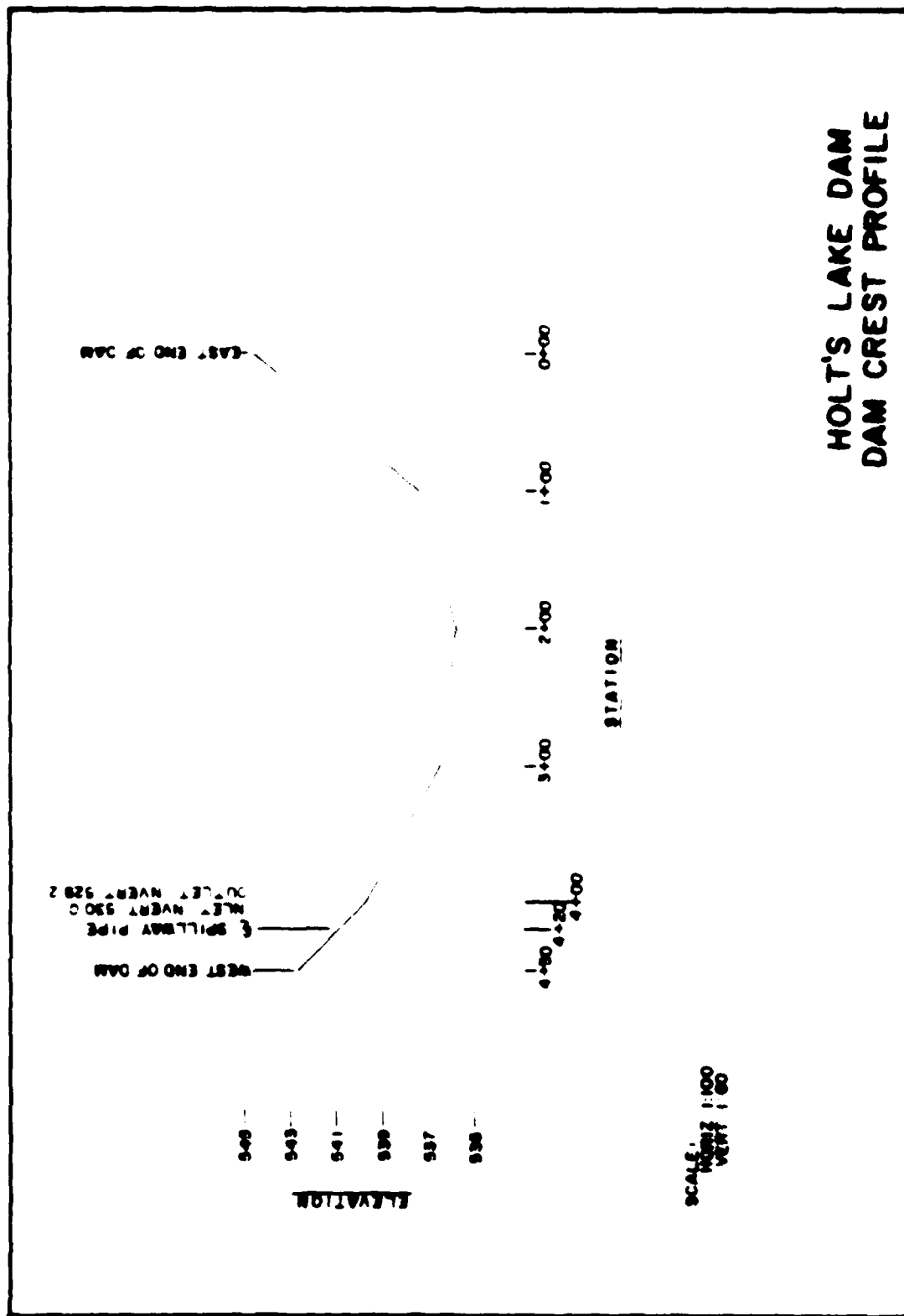


PLATE 5

LEGEND

PHOTO NO.
①
DIRECTION

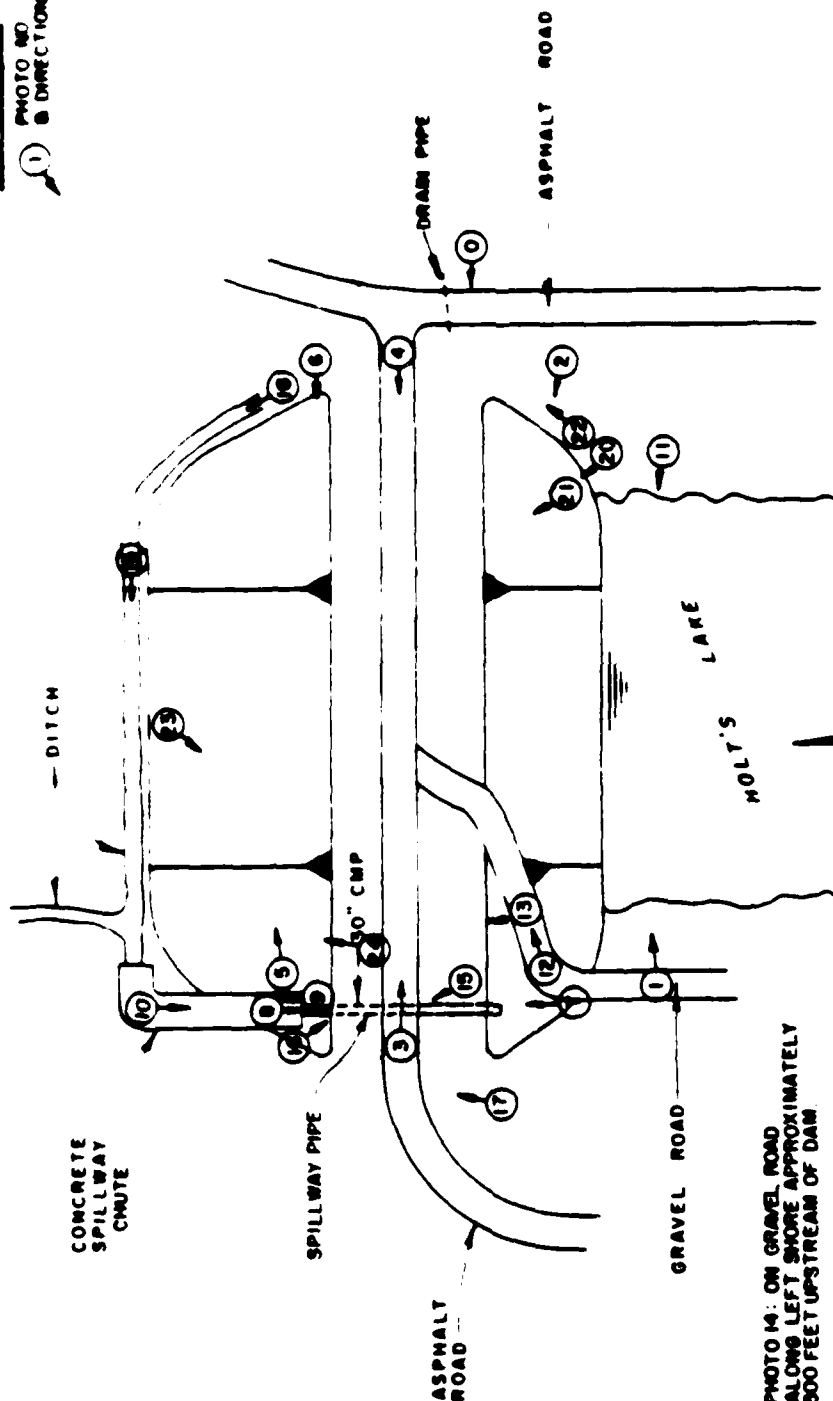


PHOTO 14: ON GRAVEL ROAD
ALONG LEFT SHORE APPROXIMATELY
900 FEET UPSTREAM OF DAM

HOLT'S LAKE DAM PHOTO INDEX

SCALE IN FEET
0 100 200

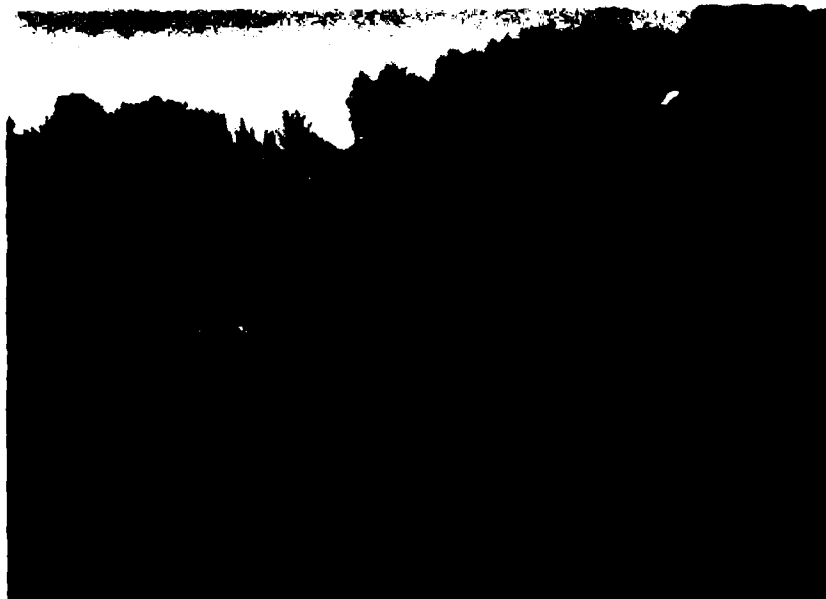


PHOTO 1: UPSTREAM FACE OF DAM

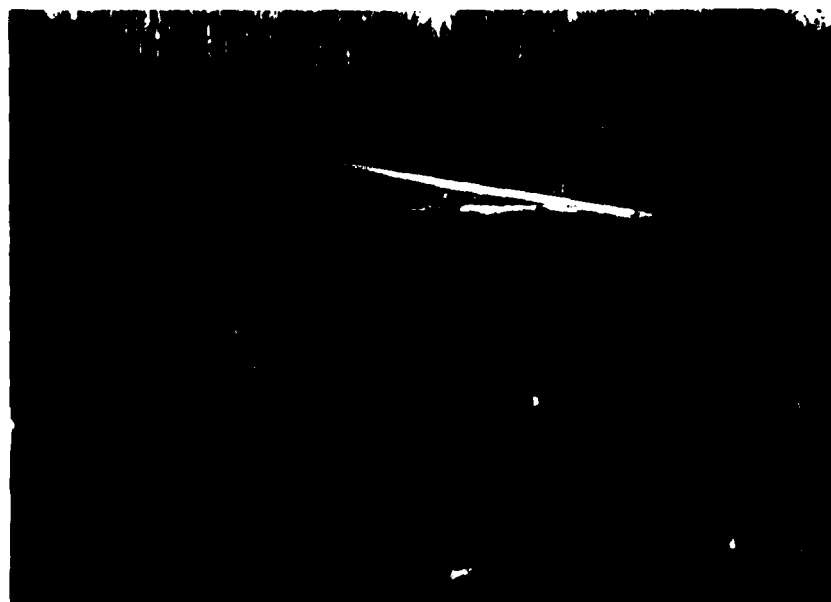


PHOTO 2: UPSTREAM FACE OF DAM LOOKING WEST



PHOTO 3: CREST OF DAM



PHOTO 4: CREST OF DAM LOOKING WEST



PHOTO 5: DOWNSTREAM FACE OF DAM



PHOTO 6: DOWNSTREAM FACE OF DAM LOOKING WEST



PHOTO 7: INLET END SPILLWAY PIPE



PHOTO 8: OUTLET END SPILLWAY PIPE



PHOTO 9: CONCRETE CHUTE DOWNSTREAM OF SPILLWAY PIPE



PHOTO 10: CONCRETE CHUTE LOOKING UPSTREAM



PHOTO 11: OVERVIEW OF CONSTRUCTION ROAD



PHOTO 12: CONSTRUCTION ROAD ON UPSTREAM FACE OF DAM



PHOTO 13: CONSTRUCTION ROAD CUT ON UPSTREAM FACE

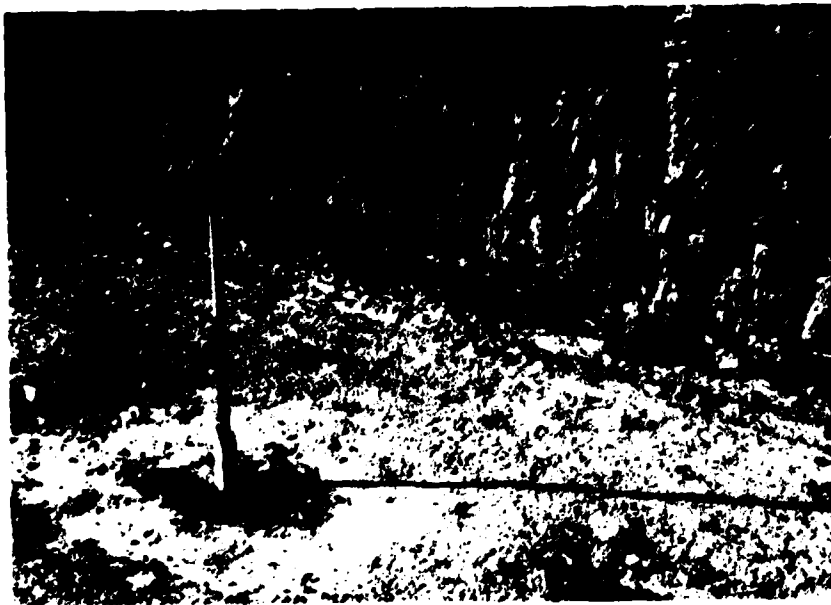


PHOTO 14: GROUT HOLE IN CONSTRUCTION ROAD

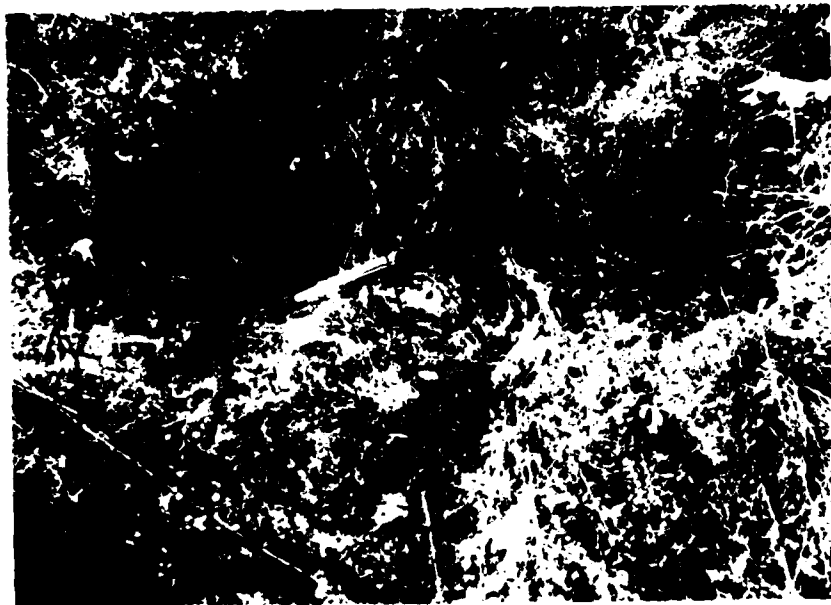


PHOTO 15: EROSION OF UPSTREAM FACE ABOVE SPILLWAY PIPE

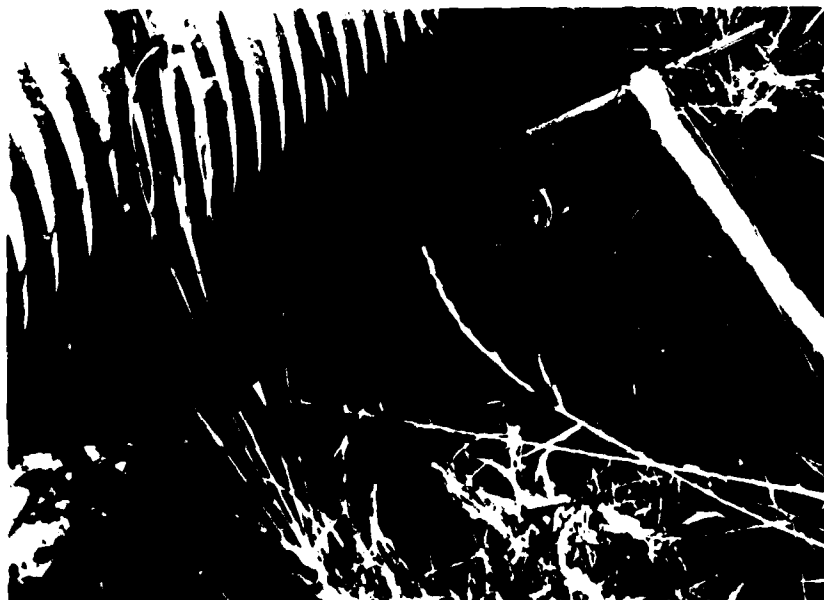


PHOTO 16: UNDERCUTTING OF SPILLWAY PIPE NEAR OUTLET



PHOTO 17: EROSION OF UPSTREAM FACE AT LEFT ABUTMENT

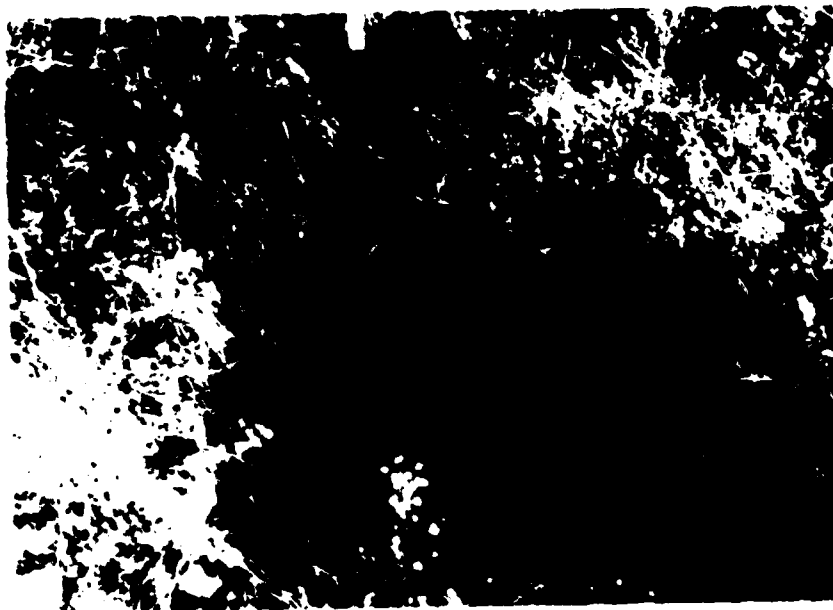


PHOTO 18: EROSION OF DOWNSTREAM FACE AT RIGHT ABUTMENT

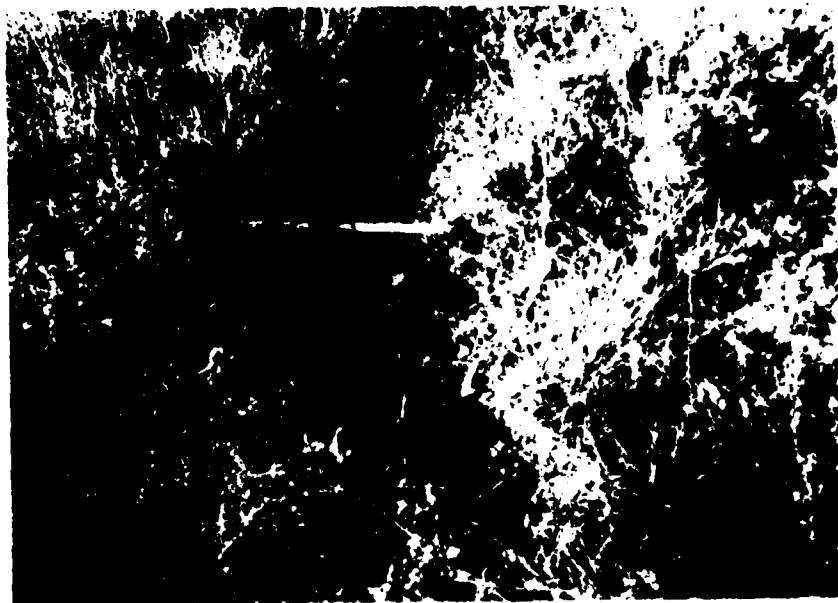


PHOTO 19: EROSION OF DOWNSTREAM TOE OF SLOPE



PHOTO 20: OVERVIEW OF EROSION OF UPSTREAM FACE NEAR RIGHT END



PHOTO 21: CLOSE-UP OF EROSION OF UPSTREAM FACE NEAR RIGHT END



PHOTO 22: EROSION AND RIPRAP BELOW DRAIN PIPE RIGHT ABUTMENT

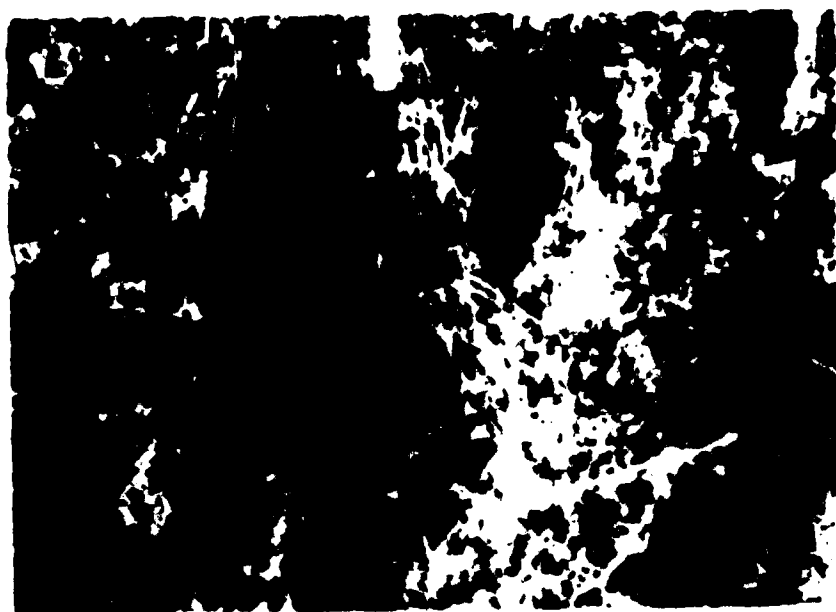


PHOTO 13 - ANIMAL BURROW IN SOWN BEAM FAULT



PHOTO 14 - SOWN BEAM FAULT NEAR ANIMAL BURROW

APPENDIX A
HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC ANALYSES

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was determined using the computer program HEC-1 (Dam Safety version 1.0).

The PMP was determined from regional charts prepared by the National Weather Service in Hydrometeorological Report No. 27 (HMR-27). Reduction factors were not applied. The rainfall distribution for the 48-hour PMP storm was determined according to the procedures outlined in HMR-27 and FM 100-2-2. The St. Louis, Missouri rainfall distribution (1 min interval, 48 hours duration), as provided by the St. Louis District Corps of Engineers, was used when the one percent chance probability flood was routed through the reservoir and spillway.

The synthetic unit hydrograph for the watershed was developed by the computer program using the Soil Conservation Service (SCS) method (1.5). The hydrograph lag time was calculated by the SCS curve number method. The value obtained was verified by the Kirpich formula. The parameters for the unit hydrograph are shown in Table 1.

The SCS curve number (CN) method was used in computing the infiltration losses for the rainfall-runoff relationship. The CN values used, and the result from the computer output, are shown in Table 2.

The reservoir routing was performed using the modified Puls method. The initial reservoir pool elevation for the routing of each storm was determined to be equivalent to the invert elevation of the spillway pipe at elevation 530.0 feet m.s.l. in accordance with antecedent storm conditions AMC II, and AMC III preceding the one percent probability and probable maximum storms respectively, as outlined by the U.S. Army Corps of Engineers, St. Louis District (4). The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation, surface area, storage, and discharge relationships shown in Table 3.

The rating curve for the spillway is shown in Table 4. Spillway discharges are based on a pipe culvert flowing under inlet control (6). The flow over the crest of the dam was determined using the non-level dam crest option (SL and SV cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir.

The result of the routing analysis indicates that the spillway will pass a flood equivalent to 10 percent of the PMP without overtopping the dam.

A summary of the routing analysis for different ratios of the PMF is shown in Table 5.

The computer input data and a summary of the output data are presented at the back of this appendix.

TABLE 1
SYNTHETIC UNIT HYDROGRAPH

Parameters

Drainage Area (A)	259 acres	
Hydraulic Length of watercourse (L)	5,240 feet	
Hydrologic Soil cover Complex Number (CN)	85 (AMC III)	70 (AMC II)
Average watershed Land Slope (S)	2.4%	
Lag time (t _g)	0.65 hours (AMC III)	1.0 hours (AMC II)
Time of concentration (T _c)	1.1 hours (AMC III)	1.7 hours (AMC II)
Duration (D)	9 min. (AMC III)	13 min. (AMC II)
	(use 10 minutes in each case)	

Time (Min.)	Discharge (cfs) *	
	AMC II	AMC III
0	0	0
10	12	33
20	36	105
30	73	208
40	122	261
50	160	255
60	177	213
70	177	150
80	162	100
90	141	69
100	113	49
110	83	33
120	65	23

From HEC-1 computer output

TABLE 1 (Continued)

FORMULAS USED

$$I_R = \frac{0.8 \times (S + 1)}{1,900 \times Y^{0.5}} \quad (7)$$

$$S = \frac{1000}{CN} - 10$$

$$T_c = I_R \times 0.6$$

$$D = 0.133 T_c$$

TABLE 2
RAINFALL-RUNOFF VALUES

<u>Selected Storm Event</u>	<u>Storm Duration (Hours)</u>	<u>Rainfall (Inches)</u>	<u>Runoff (Inches)</u>	<u>Loss (Inches)</u>
PMP	48	35.28	33.25	2.03
1% Probability	48	8.78	5.14	3.64

Additional Data:

- 1) No information on soil associations was available for this watershed.
100 percent of drainage area is hydrologic soil Group C
90 percent of the land use was timberland
10 percent of the land use was urban development
- 2) SCS Runoff Curve CN = 85 (AMC III) for the PMF.
- 3) SCS Runoff Curve CN = 70 (AMC II) for the one percent probability flood.

TABLE 3
ELEVATION, SURFACE AREA, STORAGE, AND DISCHARGE RELATIONSHIPS

<u>Elevation (feet-MSL)</u>	<u>Lake Surface Area (acres)</u>	<u>Lake Storage (acre-ft)</u>	<u>Spillway Discharge (cfs)</u>
*530.0	14.5	226	0
**535.8	20.5	327	43
***538.4	23.2	382	54

*Spillway Crest Elevation
**Top of Dam Elevation
***PMF Pool Level

The relationships in Table 3 were developed from the Chesterfield, Missouri 7.5 minute quadrangle map and the field measurements.

TABLE 4
SPILLWAY RATING CURVE

<u>Reservoir Elevation (ft)</u>	<u>Spillway Discharge (cfs)</u>
*530.0	0
532.0	14
534.0	33
**535.8	43
538.0	53
540.0	60

*Spillway Crest Elevation

**Top of Dam Elevation

METHOD USED:

Spillway release rates are based on nomographs for a pipe culvert with inlet control (6).

TABLE 5
RESULTS OF FLOOD ROUTINGS

<u>Ratio of PMF</u>	<u>Peak Inflow (CFS)</u>	<u>Peak Lake Elevation (ft.-MSL)</u>	<u>Total Storage (AC.-FT.)</u>	<u>Peak Outflow (CFS)</u>	<u>Depth (ft.) Over Top of Dam</u>	<u>Duration Over Top of Dam (Hrs.)</u>
-	0	*530.0	92	0	-	-
0.15	363	535.0	311	39	0	-
0.50	1,210	537.6	364	1,100	1.8	9.0
1.00	2,420	538.4	382	2,290	2.6	12.0

* Spillway crest elevation

- (1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Modification April 1980, Davis, California.
- (2) HMR 33, Seasonal Variations of Probable Maximum Precipitation, East of the 105th Meridian for Areas 10 to 1000 Square Miles and Durations from 6 to 48 Hours, U.S. Department of Commerce, NOAA, National Weather Service, 1956.
- (3) EM-1110-2-1411, Standard Project Flood Determinations, U.S. Army Corps of Engineers, 26 March 1952.
- (4) U.S. Army Corps of Engineers, St. Louis District, Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams, 22 August 1980.
- (5) U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1974, Washington, D.C.
- (6) U.S. Department of Commerce, Bureau of Public Roads, Hydraulic Charts For The Selection Of Highway Culverts, December 1965.
- (7) U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, August 1972.

PROJECT Q176: DATE 09 JAN 87 PAGE 4
PROGRAM M21/02-1V TIME 00:55:09 CASE

0 L A C K E V E A T C M
FLOOD HYDROGRAPH PACKAGE - MFC-1

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

PUNDT HYDROGRAPH AT HEAD
ROUTE HYDROGRAPH TO BAR
END OF NETWORK

PROJECT Q176: DATE 09 JAN 87 PAGE 4
PROGRAM M21/02-1V TIME 00:55:09 CASE

0 L A C K E V E A T C M
FLOOD HYDROGRAPH PACKAGE - MFC-1

[illegible]

CG 846 (J) NOTIFICATION 1507
DEL ATOR MISSION SATISFIED
11-2(M) 3900Z WARRIOR COTA
.....

DISCURE DAN INSPECTIONS
MOLT'S LAMP
PMP AND RAYICS

[illegible]

MULTI-PLAN ANALYSIS TO BE PERFORMED

[illegible]

SYSTEMS BLIND COMPUTATION

CALCULATE IMPACT HYPOCENPH TO LATE

C	C	I	C	O	C	C	D		093M
01701	300151	30001	1007	1107	3001	0031	0001		00151

WDR66GRAPH DATA

TABLE	SWAP	INSDA	INSPC	INATC	INSON	ISAMP	LOCAL
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PRICING DATA

SP16	P 5	06	024	048	072
00	25-20	101-00	125-00	142-00	00

LOSS DATA

LOOP	START	BLTRN	RTCL	COIN	STNS	RTCK	STRTL	CHSL	ALSN	RTTP
1	00	00	1.00	00	00	1.00	-1.00	-85.00	00	00
2	00	00	1.00	00	00	1.00	-1.00	-85.00	00	00

CO-58 - 22 127111 00'- - 553117 03'- - 30 JAN 62

UNCLAS//NOFORN//NF

[illegible]

APPROSSION DATA

63° - 45280 33° - 561815

1. The first step is to identify the problem or question that needs to be answered. This involves understanding the context and the specific requirements of the task.

UNION HYDROGRAPH 21 (NO OF PLICED COORDINATES. TC= .0C MOUS, LAG= .0S VOL= 1.00

Year	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100																																					
1905	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337

35. 28. 16. 11. 4. 5. 6. 7. 8.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1

WFO 01-0100 1100

[illegible]

MO-BA	MO-PA	PERIOD	RAIN	ENTS	LESS	IND-OF-REINS FLOW	MO-BA	MO-PA	PERIOD	RAIN	ENTS	LESS	COMP
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1-01	1-01	2	00	00	00	0	1-02	1-01	146	01	00	00	0
1-01	1-01	3	00	00	00	0	1-02	1-01	147	01	00	00	0
1-01	1-01	4	00	00	00	0	1-02	1-01	148	01	00	00	0
1-01	1-01	5	00	00	00	0	1-02	1-01	149	01	00	00	0
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1-01	1-01	27	00	00	00	0	1-02	1-01	171	01	00	00	0
1-01	1-01	28	00	00	00	0	1-02	1-01	172	01	00	00	0
1-01	1-01	29	00	00	00	0	1-02	1-01	173	01	00	00	0
1-01	1-01	30	00	00	00	0	1-02	1-01	174	01	00	00	0
1-01	1-01	31	00	00	00	0	1-02	1-01	175	01	00	00	0
1-01	1-01	32	00	00	00	0	1-02	1-01	176	01	00	00	0
1-01	1-01	33	00	00	00	0	1-02	1-01	177	01	00	00	0
1-01	1-01	34	00	00	00	0	1-02	1-01	178	01	00	00	0
1-01	1-01	35	00	00	00	0	1-02	1-01	179	01	00	00	0
1-01	1-01	36	00	00	00	0	1-02	1-01	180	01	00	00	0
1-01	1-01	37	01	00	01	0	1-02	1-01	181	01	00	00	0
1-01	1-01	38	01	00	01	0	1-02	1-01	182	01	00	00	0
1-01	1-01	39	01	00	01	0	1-02	1-01	183	01	00	00	0
1-01	1-01	40	01	00	01	0	1-02	1-01	184	01	00	00	0
1-01	1-01	41	01	00	01	0	1-02	1-01	185	01	00	00	0
1-01	1-01	42	01	00	01	0	1-02	1-01	186	01	00	00	0
1-01	1-01	43	01	00	01	0	1-02	1-01	187	01	00	00	0
1-01	1-01	44	01	00	01	0	1-02	1-01	188	01	00	00	0
1-01	1-01	45	01	00	01	0	1-02	1-01	189	01	00	00	0
1-01	1-01	46	01	00	01	0	1-02	1-01	190	01	00	00	0
1-01	1-01	47	01	00	01	0	1-02	1-01	191	01	00	00	0
1-01	1-01	48	01	00	01	0	1-02	1-01	192	01	00	00	0
1-01	1-01	49	01	00	01	0	1-02	1-01	193	01	00	00	0
1-01	1-01	50	01	00	01	0	1-02	1-01	194	01	00	00	0
1-01	1-01	51	01	00	01	0	1-02	1-01	195	01	00	00	0
1-01	1-01	52	01	00	01	0	1-02	1-01	196	01	00	00	0
1-01	1-01	53	01	00	01	0	1-02	1-01	197	01	00	00	0

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BLANK 2 V E A T C M
FLOOD HYDROGRAPH PACKAGE - MC-1
PROJECT 01AC:
DATE 29 JAN 74 PAGE 4
TIME 00:00
PROGRAM M21C2-1

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B L A C K V I A T I C M
FLOOD HYDROGRAPH PACKAGE - HEC-1
PROJECT 01763 DATE 09 JAN 81 PAGE 1
PROGRAM H21/02-IV TIME 00:55:17 CASE

1.01	9.70	54	.01	.00	.01	0.	1.02	5.00	192	.11	.11	.11	.11	151.
1.01	9.70	55	.01	.00	.01	0.	1.02	9.70	199	.11	.11	.11	.11	151.
1.01	9.70	56	.01	.00	.01	0.	1.02	9.70	200	.11	.11	.11	.11	151.
1.01	9.70	57	.01	.00	.01	0.	1.02	9.70	201	.11	.11	.11	.11	151.
1.01	9.70	58	.01	.00	.01	0.	1.02	9.70	202	.11	.11	.11	.11	151.
1.01	9.70	59	.01	.00	.01	0.	1.02	9.70	203	.11	.11	.11	.11	151.
1.01	9.70	60	.01	.00	.01	0.	1.02	9.70	204	.11	.11	.11	.11	151.
1.01	9.70	61	.01	.00	.01	0.	1.02	9.70	205	.11	.11	.11	.11	151.
1.01	9.70	62	.01	.00	.01	0.	1.02	9.70	206	.11	.11	.11	.11	151.
1.01	9.70	63	.01	.00	.01	0.	1.02	9.70	207	.11	.11	.11	.11	151.
1.01	9.70	64	.01	.00	.01	0.	1.02	9.70	208	.11	.11	.11	.11	151.
1.01	9.70	65	.01	.00	.01	0.	1.02	9.70	209	.11	.11	.11	.11	151.
1.01	9.70	66	.01	.00	.01	0.	1.02	9.70	210	.11	.11	.11	.11	151.
1.01	9.70	67	.01	.00	.01	0.	1.02	9.70	211	.11	.11	.11	.11	151.
1.01	9.70	68	.01	.00	.01	0.	1.02	9.70	212	.11	.11	.11	.11	151.
1.01	9.70	69	.01	.00	.01	0.	1.02	9.70	213	.11	.11	.11	.11	151.
1.01	9.70	70	.01	.00	.01	0.	1.02	9.70	214	.11	.11	.11	.11	151.
1.01	9.70	71	.01	.00	.01	0.	1.02	9.70	215	.11	.11	.11	.11	151.
1.01	9.70	72	.01	.00	.01	0.	1.02	9.70	216	.11	.11	.11	.11	151.
1.01	9.70	73	.01	.00	.01	0.	1.02	9.70	217	.11	.11	.11	.11	151.
1.01	9.70	74	.01	.00	.01	0.	1.02	9.70	218	.11	.11	.11	.11	151.
1.01	9.70	75	.01	.00	.01	0.	1.02	9.70	219	.11	.11	.11	.11	151.
1.01	9.70	76	.01	.00	.01	0.	1.02	9.70	220	.11	.11	.11	.11	151.
1.01	9.70	77	.01	.00	.01	0.	1.02	9.70	221	.11	.11	.11	.11	151.
1.01	9.70	78	.01	.00	.01	0.	1.02	9.70	222	.11	.11	.11	.11	151.
1.01	9.70	79	.01	.00	.01	0.	1.02	9.70	223	.11	.11	.11	.11	151.
1.01	9.70	80	.01	.00	.01	0.	1.02	9.70	224	.11	.11	.11	.11	151.
1.01	9.70	81	.01	.00	.01	0.	1.02	9.70	225	.11	.11	.11	.11	151.
1.01	9.70	82	.01	.00	.01	0.	1.02	9.70	226	.11	.11	.11	.11	151.
1.01	9.70	83	.01	.00	.01	0.	1.02	9.70	227	.11	.11	.11	.11	151.
1.01	9.70	84	.01	.00	.01	0.	1.02	9.70	228	.11	.11	.11	.11	151.
1.01	9.70	85	.01	.00	.01	0.	1.02	9.70	229	.11	.11	.11	.11	151.
1.01	9.70	86	.01	.00	.01	0.	1.02	9.70	230	.11	.11	.11	.11	151.
1.01	9.70	87	.01	.00	.01	0.	1.02	9.70	231	.11	.11	.11	.11	151.
1.01	9.70	88	.01	.00	.01	0.	1.02	9.70	232	.11	.11	.11	.11	151.
1.01	9.70	89	.01	.00	.01	0.	1.02	9.70	233	.11	.11	.11	.11	151.
1.01	9.70	90	.01	.00	.01	0.	1.02	9.70	234	.11	.11	.11	.11	151.
1.01	9.70	91	.01	.00	.01	0.	1.02	9.70	235	.11	.11	.11	.11	151.
1.01	9.70	92	.01	.00	.01	0.	1.02	9.70	236	.11	.11	.11	.11	151.
1.01	9.70	93	.01	.00	.01	0.	1.02	9.70	237	.11	.11	.11	.11	151.
1.01	9.70	94	.01	.00	.01	0.	1.02	9.70	238	.11	.11	.11	.11	151.
1.01	9.70	95	.01	.00	.01	0.	1.02	9.70	239	.11	.11	.11	.11	151.
1.01	9.70	96	.01	.00	.01	0.	1.02	9.70	240	.11	.11	.11	.11	151.
1.01	9.70	97	.01	.00	.01	0.	1.02	9.70	241	.11	.11	.11	.11	151.
1.01	9.70	98	.01	.00	.01	0.	1.02	9.70	242	.11	.11	.11	.11	151.
1.01	9.70	99	.01	.00	.01	0.	1.02	9.70	243	.11	.11	.11	.11	151.
1.01	9.70	100	.01	.00	.01	0.	1.02	9.70	244	.11	.11	.11	.11	151.
1.01	9.70	101	.01	.00	.01	0.	1.02	9.70	245	.11	.11	.11	.11	151.
1.01	9.70	102	.01	.00	.01	0.	1.02	9.70	246	.11	.11	.11	.11	151.
1.01	9.70	103	.01	.00	.01	0.	1.02	9.70	247	.11	.11	.11	.11	151.
1.01	9.70	104	.01	.00	.01	0.	1.02	9.70	248	.11	.11	.11	.11	151.
1.01	9.70	105	.01	.00	.01	0.	1.02	9.70	249	.11	.11	.11	.11	151.
1.01	9.70	106	.01	.00	.01	0.	1.02	9.70	250	.11	.11	.11	.11	151.
1.01	9.70	107	.01	.00	.01	0.	1.02	9.70	251	.11	.11	.11	.11	151.
1.01	9.70	108	.01	.00	.01	0.	1.02	9.70	252	.11	.11	.11	.11	151.
1.01	9.70	109	.01	.00	.01	0.	1.02	9.70	253	.11	.11	.11	.11	151.

B L A C K V I A T I C M
FLOOD HYDROGRAPH PACKAGE - HEC-1
PROJECT 01763 DATE 09 JAN 81 PAGE 1
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BLACK & VEATCH

FLOOD HYDROGRAPH PACKAGE - HEC-1

1-01	18-20	110	-00	-00	-00	-00	-00	-00	-00	1-02	18-20	214	-04	712
1-01	18-20	111	-00	-00	-00	-00	-00	-00	-00	1-02	18-20	215	-04	713
1-01	18-40	112	-00	-00	-00	-00	-00	-00	-00	1-02	18-40	216	-04	714
1-01	18-40	113	-00	-00	-00	-00	-00	-00	-00	1-02	18-40	217	-04	715
1-01	18-20	114	-00	-00	-00	-00	-00	-00	-00	1-02	18-20	218	-04	716
1-01	18-20	115	-00	-00	-00	-00	-00	-00	-00	1-02	18-20	219	-04	717
1-01	18-20	116	-00	-00	-00	-00	-00	-00	-00	1-02	18-20	220	-04	718
1-01	18-20	117	-00	-00	-00	-00	-00	-00	-00	1-02	18-20	221	-04	719
1-01	18-40	118	-00	-00	-00	-00	-00	-00	-00	1-02	18-40	222	-04	720
1-01	18-20	119	-00	-00	-00	-00	-00	-00	-00	1-02	18-20	223	-04	721
1-01	20-20	120	-00	-00	-00	-00	-00	-00	-00	1-02	20-20	224	-04	722
1-01	20-20	121	-00	-00	-00	-00	-00	-00	-00	1-02	20-20	225	-04	723
1-01	20-20	122	-00	-00	-00	-00	-00	-00	-00	1-02	20-20	226	-04	724
1-01	20-20	123	-00	-00	-00	-00	-00	-00	-00	1-02	20-20	227	-04	725
1-01	20-40	124	-00	-00	-00	-00	-00	-00	-00	1-02	20-40	228	-04	726
1-01	20-20	125	-00	-00	-00	-00	-00	-00	-00	1-02	20-20	229	-04	727
1-01	21-20	126	-00	-00	-00	-00	-00	-00	-00	1-02	21-20	230	-04	728
1-01	21-20	127	-00	-00	-00	-00	-00	-00	-00	1-02	21-20	231	-04	729
1-01	21-20	128	-00	-00	-00	-00	-00	-00	-00	1-02	21-20	232	-04	730
1-01	21-40	129	-00	-00	-00	-00	-00	-00	-00	1-02	21-40	233	-04	731
1-01	21-40	130	-00	-00	-00	-00	-00	-00	-00	1-02	21-40	234	-04	732
1-01	21-20	131	-00	-00	-00	-00	-00	-00	-00	1-02	21-20	235	-04	733
1-01	22-20	132	-00	-00	-00	-00	-00	-00	-00	1-02	22-20	236	-04	734
1-01	22-10	133	-00	-00	-00	-00	-00	-00	-00	1-02	22-10	237	-04	735
1-01	22-20	134	-00	-00	-00	-00	-00	-00	-00	1-02	22-20	238	-04	736
1-01	22-20	135	-00	-00	-00	-00	-00	-00	-00	1-02	22-20	239	-04	737
1-01	22-40	136	-00	-00	-00	-00	-00	-00	-00	1-02	22-40	240	-04	738
1-01	22-50	137	-00	-00	-00	-00	-00	-00	-00	1-02	22-50	241	-04	739
1-01	23-20	138	-00	-00	-00	-00	-00	-00	-00	1-02	23-20	242	-04	740
1-01	23-10	139	-00	-00	-00	-00	-00	-00	-00	1-02	23-10	243	-04	741
1-01	23-20	140	-00	-00	-00	-00	-00	-00	-00	1-02	23-20	244	-04	742
1-01	23-20	141	-00	-00	-00	-00	-00	-00	-00	1-02	23-20	245	-04	743
1-01	23-40	142	-00	-00	-00	-00	-00	-00	-00	1-02	23-40	246	-04	744
1-01	23-50	143	-	-	-	-	-	-	-	1-02	23-50	247	-04	745
1-02	-00	144	-00	-00	-00	-00	-00	-00	-00	1-02	-00	248	-04	746

[illegible]

0 7 4 2 3 4 5 6 7 8 9

FLOOR HYDROGRAPH PAGE - 15C-1

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[illegible]

4.	4.	4.	5.	7.	11.	17.	27.
20.	31.	37.	34.	24.	31.	37.	37.
36.	36.	36.	34.	36.	37.	37.	37.
37.	37.	37.	37.	37.	37.	37.	37.
41.	50.	76.	116.	130.	151.	177.	177.
170.	182.	187.	186.	189.	191.	191.	191.
181.	191.	194.	194.	194.	194.	194.	194.
197.	197.	197.	197.	197.	197.	197.	197.
197.	197.	197.	197.	197.	197.	197.	197.
461.	504.	551.	628.	647.	696.	741.	741.
802.	843.	878.	908.	949.	1011.	1074.	1074.
2421.	2376.	1865.	1725.	1537.	1235.	1101.	914.
821.	826.	719.	606.	489.	377.	277.	181.
132.	111.	96.	78.	75.	69.	62.	47.
86.	65.	45.	45.	45.	45.	45.	45.
65.	65.	65.	65.	65.	65.	65.	65.

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2421.	1000.	176.	1114.
CFS	69.	10.	5.	1449.
INCHES	24.48	31.63	33.03	33.03
MM	626.50	808.96	838.96	838.96
AC-FT	571.	479.	704.	704.
THOUS CU R	643.	878.	889.	889.

ROUTE HYDROGRAPH: PAST DAM
HYDROGRAPH ROUTINE

STAGE	ICOMP	IFCON	ITYPE	JPLY	JPT	INAME	ISTAGE	1AUTC
530.00	531.00	532.00	533.00	534.00	535.00	536.00	537.00	538.00
FLON	5.00	14.00	26.00	37.00	45.00	57.00	60.00	77.00
SURFACE AREA	0.	0.	14.	25.	35.	48.		
CAPACITY	0.	115.	226.	421.	721.	1134.		
ELEVATION	492.	520.	530.	540.	550.	560.		
REL SPID	525.0	50.	50.	50.	50.	50.		
COOL	525.0	50.	50.	50.	50.	50.		
CAREA	525.0	50.	50.	50.	50.	50.		
ENPL	525.0	50.	50.	50.	50.	50.		

DAM DATA

SUMMARY OF DAM SAFETY ANALYSIS

PLUM 1	ELEVATION AVG OUTLET	INITIAL VALUE 510.00 220. 6.	SPILLWAY TEST 510.00 220. 0.	TOP OF DAM 515.00 322. 45.	TYPE OF FAILURE MODE
01	515.00	515.00	515.00	515.00	01
02	515.00	515.00	515.00	515.00	02
03	515.00	515.00	515.00	515.00	03
04	515.00	515.00	515.00	515.00	04
05	515.00	515.00	515.00	515.00	05
06	515.00	515.00	515.00	515.00	06
07	515.00	515.00	515.00	515.00	07
08	515.00	515.00	515.00	515.00	08
09	515.00	515.00	515.00	515.00	09
10	515.00	515.00	515.00	515.00	10
11	515.00	515.00	515.00	515.00	11
12	515.00	515.00	515.00	515.00	12
13	515.00	515.00	515.00	515.00	13
14	515.00	515.00	515.00	515.00	14
15	515.00	515.00	515.00	515.00	15
16	515.00	515.00	515.00	515.00	16
17	515.00	515.00	515.00	515.00	17
18	515.00	515.00	515.00	515.00	18
19	515.00	515.00	515.00	515.00	19
20	515.00	515.00	515.00	515.00	20
21	515.00	515.00	515.00	515.00	21
22	515.00	515.00	515.00	515.00	22
23	515.00	515.00	515.00	515.00	23
24	515.00	515.00	515.00	515.00	24
25	515.00	515.00	515.00	515.00	25
26	515.00	515.00	515.00	515.00	26
27	515.00	515.00	515.00	515.00	27
28	515.00	515.00	515.00	515.00	28
29	515.00	515.00	515.00	515.00	29
30	515.00	515.00	515.00	515.00	30
31	515.00	515.00	515.00	515.00	31
32	515.00	515.00	515.00	515.00	32
33	515.00	515.00	515.00	515.00	33
34	515.00	515.00	515.00	515.00	34
35	515.00	515.00	515.00	515.00	35
36	515.00	515.00	515.00	515.00	36
37	515.00	515.00	515.00	515.00	37
38	515.00	515.00	515.00	515.00	38
39	515.00	515.00	515.00	515.00	39
40	515.00	515.00	515.00	515.00	40
41	515.00	515.00	515.00	515.00	41
42	515.00	515.00	515.00	515.00	42
43	515.00	515.00	515.00	515.00	43
44	515.00	515.00	515.00	515.00	44
45	515.00	515.00	515.00	515.00	45
46	515.00	515.00	515.00	515.00	46
47	515.00	515.00	515.00	515.00	47
48	515.00	515.00	515.00	515.00	48
49	515.00	515.00	515.00	515.00	49
50	515.00	515.00	515.00	515.00	50
51	515.00	515.00	515.00	515.00	51
52	515.00	515.00	515.00	515.00	52
53	515.00	515.00	515.00	515.00	53
54	515.00	515.00	515.00	515.00	54
55	515.00	515.00	515.00	515.00	55
56	515.00	515.00	515.00	515.00	56
57	515.00	515.00	515.00	515.00	57
58	515.00	515.00	515.00	515.00	58
59	515.00	515.00	515.00	515.00	59
60	515.00	515.00	515.00	515.00	60
61	515.00	515.00	515.00	515.00	61
62	515.00	515.00	515.00	515.00	62
63	515.00	515.00	515.00	515.00	63
64	515.00	515.00	515.00	515.00	64
65	515.00	515.00	515.00	515.00	65
66	515.00	515.00	515.00	515.00	66
67	515.00	515.00	515.00	515.00	67
68	515.00	515.00	515.00	515.00	68
69	515.00	515.00	515.00	515.00	69
70	515.00	515.00	515.00	515.00	70
71	515.00	515.00	515.00	515.00	71
72	515.00	515.00	515.00	515.00	72
73	515.00	515.00	515.00	515.00	73
74	515.00	515.00	515.00	515.00	74
75	515.00	515.00	515.00	515.00	75
76	515.00	515.00	515.00	515.00	76
77	515.00	515.00	515.00	515.00	77
78	515.00	515.00	515.00	515.00	78
79	515.00	515.00	515.00	515.00	79
80	515.00	515.00	515.00	515.00	80
81	515.00	515.00	515.00	515.00	81
82	515.00	515.00	515.00	515.00	82
83	515.00	515.00	515.00	515.00	83
84	515.00	515.00	515.00	515.00	84
85	515.00	515.00	515.00	515.00	85
86	515.00	515.00	515.00	515.00	86
87	515.00	515.00	515.00	515.00	87
88	515.00	515.00	515.00	515.00	88
89	515.00	515.00	515.00	515.00	89
90	515.00	515.00	515.00	515.00	90
91	515.00	515.00	515.00	515.00	91
92	515.00	515.00	515.00	515.00	92
93	515.00	515.00	515.00	515.00	93
94	515.00	515.00	515.00	515.00	94
95	515.00	515.00	515.00	515.00	95
96	515.00	515.00	515.00	515.00	96
97	515.00	515.00	515.00	515.00	97
98	515.00	515.00	515.00	515.00	98
99	515.00	515.00	515.00	515.00	99
100	515.00	515.00	515.00	515.00	100

PROJECT 9142 DATE 20 JAN 81
 PROGRAM W21/C2-1V 1100 001512Z CAS

BLA C V E A T C M
 FLOOD HYDROGRAPH PACKAGE - REC-1

51	50535.8								
52	5120.	50.	147.	250.	332.	366.	422.	480.	
53	50535.7	535.8	536.4	537.6	538.4	540.4	542.7	545.	
54	99								
55	A								
56	A								
57	A								
58	A								
59	A								

PROJECT 9142 DATE 20 JAN 81
 PROGRAM W21/C2-1V 1100 001512Z CAS

BLA C V E A T C M
 FLOOD HYDROGRAPH PACKAGE - REC-1

PROJECT 9366: DATE 09 JAN 87 PAGE 5
TIME 09:55:29
PROGRAM #21/02-1V 1301 09:55:29 CASH

BLANK VIEW
FLOOD HYDROGRAPH PACKAGE - REC-1

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

ROUTING HYDROGRAPH AT HEAD
ROUTING HYDROGRAPH TO DAM
END OF NETWORK

PROJECT 9366: DATE 09 JAN 87 PAGE 5
TIME 09:55:29
PROGRAM #21/02-1V 1301 09:55:29 CASH

BLANK VIEW
FLOOD HYDROGRAPH PACKAGE - REC-1


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B I O D I A N T V A M .....  
.....  
F L O O D H Y G R A P H - M E C - 1 ....  
P R O G R A M P Z I J A .....  
C O S S . 6 0 J I B .....  
J A N 8 0 1 9 8 0
```

SECRET

FLOOD HYDROGRAPH PACKAGE - HEC-1

1-01	4-10	28	-01	-00	-01	0-	1-02	6-00	172	-01	-00	-01
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1-01	4-10	30	-01	-00	-01	0-	1-02	5-00	174	-01	-00	-01
1-01	4-10	31	-01	-00	-01	0-	1-02	5-10	175	-01	-00	-01
1-01	4-20	32	-01	-00	-01	0-	1-02	5-20	176	-01	-00	-01
1-01	4-20	33	-01	-00	-01	0-	1-02	5-00	177	-01	-00	-01
1-01	4-00	34	-01	-00	-01	0-	1-02	5-00	178	-01	-00	-01
1-01	4-00	35	-01	-00	-01	0-	1-02	5-00	179	-01	-00	-01
1-01	4-00	36	-01	-00	-01	0-	1-02	6-00	180	-01	-00	-01
1-01	4-10	37	-01	-00	-01	0-	1-02	6-00	181	-01	-00	-01
1-01	4-10	38	-01	-00	-01	0-	1-02	6-00	182	-01	-00	-01
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1-01	6-00	41	-01	-00	-01	0-	1-02	6-00	185	-01	-00	-01
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1-01	7-00	43	-01	-00	-01	0-	1-02	7-00	187	-01	-00	-01
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1-01	8-00	50	-01	-00	-01	0-	1-02	8-00	194	-01	-00	-01
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1-01	9-00	56	-01	-00	-01	0-	1-02	9-00	200	-01	-00	-01
1-01	9-00	57	-01	-00	-01	0-	1-02	9-00	201	-01	-00	-01
1-01	9-00	58	-01	-00	-01	0-	1-02	9-00	202	-01	-00	-01
1-01	9-00	59	-01	-00	-01	0-	1-02	9-00	203	-01	-00	-01
1-01	10-00	60	-01	-00	-01	0-	1-02	10-00	204	-01	-00	-01
1-01	10-00	61	-01	-00	-01	0-	1-02	10-00	205	-01	-00	-01
1-01	10-00	62	-01	-00	-01	0-	1-02	10-00	206	-01	-00	-01
1-01	10-00	63	-01	-00	-01	0-	1-02	10-00	207	-01	-00	-01
1-01	10-00	64	-01	-00	-01	0-	1-02	10-00	208	-01	-00	-01
1-01	10-00	65	-01	-00	-01	0-	1-02	10-00	209	-01	-00	-01
1-01	11-00	66	-01	-00	-01	0-	1-02	11-00	210	-01	-00	-01
1-01	11-00											

0 L A C K E R V I A T C H DATE 09 JAN 81 PAGE 10
 0000 HYDROBAM PAC(PAGE - MFT-1) PROJECT 0107:
 0000 HYDROBAM PAC(PAGE - MFT-1) PROGRAM M21/02-1V TIME 00:03:20 CASE

DECLASSIFICATION

FLOO0 HYDROGRAPH PACKAGE - HFC-1

BLAKE V E A T C H PROJECT 0166 DATE 09 JAN 81 PAGE 9
FLOOD HYDROGRAPH PACKAGE - HEC-1 PROGRAM M24702-IV TIME 09:55:20 CASE

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1.01	16.30	83	.01	.00	.01	0.	1.02	16.30	281	.24	.04	.04	56
1.01	16.40	82	.01	.00	.01	0.	1.02	16.40	282	.31	.04	.04	56
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1.01	17.10	79	.01	.00	.01	0.	1.02	17.10	285	.52	.04	.04	84
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1.01	17.50	75	.01	.00	.01	0.	1.02	17.50	289	.80	.04	.04	112
1.01	18.00	74	.01	.00	.01	0.	1.02	18.00	290	.87	.04	.04	112
1.01	18.10	73	.01	.00	.01	0.	1.02	18.10	291	.94	.04	.04	126
1.01	18.20	72	.01	.00	.01	0.	1.02	18.20	292	1.01	.04	.04	126
1.01	18.30	71	.01	.00	.01	0.	1.02	18.30	293	1.08	.04	.04	140
1.01	18.40	70	.01	.00	.01	0.	1.02	18.40	294	1.15	.04	.04	140
1.01	18.50	69	.01	.00	.01	0.	1.02	18.50	295	1.22	.04	.04	154
1.01	19.00	68	.01	.00	.01	0.	1.02	19.00	296	1.29	.04	.04	154
1.01	19.10	67	.01	.00	.01	0.	1.02	19.10	297	1.36	.04	.04	168
1.01	19.20	66	.01	.00	.01	0.	1.02	19.20	298	1.43	.04	.04	168
1.01	19.30	65	.01	.00	.01	0.	1.02	19.30	299	1.50	.04	.04	182
1.01	19.40	64	.01	.00	.01	0.	1.02	19.40	300	1.57	.04	.04	182
1.01	19.50	63	.01	.00	.01	0.	1.02	19.50	301	1.64	.04	.04	196
1.01	20.00	62	.01	.00	.01	0.	1.02	20.00	302	1.71	.04	.04	196
1.01	20.10	61	.01	.00	.01	0.	1.02	20.10	303	1.78	.04	.04	210
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1.01	20.40	58	.01	.00	.01	0.	1.02	20.40	306	1.99	.04	.04	224
1.01	20.50	57	.01	.00	.01	0.	1.02	20.50	307	2.06	.04	.04	238
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1.01	21.20	54	.01	.00	.01	0.	1.02	21.20	310	2.27	.04	.04	252
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1.01	22.00	50	.01	.00	.01	0.	1.02	22.00	314	2.55	.04	.04	280
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BLAKE V E A T C H PROJECT 0166 DATE 09 JAN 81 PAGE 9
FLOOD HYDROGRAPH PACKAGE - HEC-1 PROGRAM M24702-IV TIME 09:55:20 CASE

1.01	23.20	42	.01	.00	.01	0.	1.02	23.20	322	.04	.04	.04	350
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Category	Count	Percentage	Count	Percentage	Count	Percentage
1-10	100	10.0%	100	10.0%	100	10.0%
11-20	100	10.0%	100	10.0%	100	10.0%
21-30	100	10.0%	100	10.0%	100	10.0%
31-40	100	10.0%	100	10.0%	100	10.0%
41-50	100	10.0%	100	10.0%	100	10.0%
51-60	100	10.0%	100	10.0%	100	10.0%
61-70	100	10.0%	100	10.0%	100	10.0%
71-80	100	10.0%	100	10.0%	100	10.0%
81-90	100	10.0%	100	10.0%	100	10.0%
91-100	100	10.0%	100	10.0%	100	10.0%
TOTAL	1000	100.0%	1000	100.0%	1000	100.0%

	PRESS	6-IN-HOLE	72-IN-HOLE	TOTAL VOLUME
C/S	502.	19.	27.	784.
CM	76.	5.	1.	222.
INCHES		2.		5.07
MM		4.19	5.07	128.70
AC-FT	106.48	122.57	128.70	108.
	79.	128.	133.	133.
TMOUS CU M	110.	113.		

ROUTE HYDROGRAPH PAST DAM

ISTAG	ICOPP	IECCN	ITAPE	JPLT	JPRY	JNAME	ISTATE	ISUTO
BAR	1	0	0	0	0	1	0	0
ROUTING DATA								
GLD'S	AVE	INFS	ISAPL	LOPI	IPMP		LSTR	
-0	-CO	1	1	0	0			
NTSTS	NTSTL	LAC	ANSHK	X	TSK	STORA	ISPRAT	
1	0	0	-070	.000	.000	-330	-1	

STAGE	530.00	531.00	532.00	533.00	534.00	535.00	536.00	540.00	550.00
FLOW	-00	5.00	14.00	26.00	33.00	42.00	53.00	60.00	90.00
SURFACE AREA	0-	3-	8-	14-	25-	35-	48-		
CAPACITY	0-	8-	115-	226-	421-	721-	1134-		
ELEVATION	492-	500-	520-	530-	540-	550-	560-		

CROSS-SECTION AT OR NEAR LATERATION	P.	147-	250-	DAP DATA			DAP-70	DAP-70 -0
				TORRELL 515-0	Q008 -0	HPD -0		
515-7	50-	147-	250-	332-	364-	427-	480-	
515-7	536-8	536-8	537-6	539-4	540-6	562-7	545-0	

L A C K S W E A T I G H
KODAK HYDROBROMIDE PAPER - NEG-1
NOV 63 08 AM 11-16-63
JAN 19 00 AM :
GPO

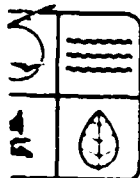
0 L A C ' V A I C H
.....
FLOOD HYDROGRAPH PACKAGE - REC-1

SYSTEMS AND METHODS

PLAN 1	ELEVATION STORAGE OUTFLOW	INITIAL VALUE 520.00 276. 0.	SPILLWAY CAPST 430.00 226. 0.	TOP OF DAM 545.80 377. 45.	TYPE OF FAILURE HOURS
100 YEAR -	MAXIMUM RESERVOIR E.S.ELEV	MAXIMUM DEPTH OUTF DAM	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TYPE OF FAILURE HOURS
3-20	333.19	.00	374.	.00	43.50

2142

APPENDIX B
GROUTING OPERATIONS



Holly Lake

October 27, 1980

J. F. Davies
Burton Duenke Construction
Senior Vice President
P. O. Box 12878
St. Louis, MO 63141

Dear Mr. Davies:

On 20 October 1980, I met with Mr. Don Ramsey and Dave Taylor of Test Drilling Services and they gave me a preview on their grouting program on the west Chesterfield Lake. I have a copy of their report of hole location, overburden depth, grout intake, etc.

It appears that most of the grout intake was at or just below the bottom of the lake with respect to elevation. The larger grout intake zones appear to be horizontal bedding planes which are probably the feeder systems that we discussed on numerous occasions. Any particular vertical fracture zone in these areas could also be the outlet for lake water into the hill to the spring system. Grouting of the horizontal feeder system, however, may be as or more important than locating the specific area where the water leaves the valley. There does not appear to be any way that the specific zone where the water leaves the valley can be located. The grouting of the feeder systems may well have taken care of the problem, at least in the area that they grouted.

I checked the spring down at Caulks Creek and it was still flowing a small quantity of water. The water was very clear and not cloudy as it has been everytime I've checked it in the past. In addition, the orifice of the spring now has at least three points where the spring water is emerging. I don't know what the significance of this is.

At Don Ramsey's suggestion, it is recommended that no more grouting can be done between station 2+55 north and the dam until sufficient rainfall or pumping has occurred to raise the water level of the lake so it can be observed for stability. It is entirely possible that the zones that they have grouted will have reduced the outflow of water sufficient to where it is not a problem any more. I believe the zones that have been grouted have been sufficiently grouted to where they should no longer present a problem. If the lake level arises considerably and then drops, I would recommend that the grouting program continue between station 2+55 and the dam.

Past conversations suggested that if the zone where water leaves the valley could be located that it be grouted above the water line in the area of the

Joseph P. Teasdale Governor
and A. Lasfer Director

Division of Geology and Land Survey
Wallace B. Howe Director

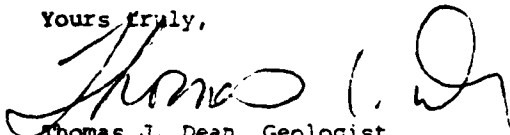
MISSOURI DEPARTMENT OF NATURAL RESOURCES
Box 250 Rolla, Missouri 65401 (314) 364-1752

J. F. Davies
October 27, 1980
Page 2

blacktop road. In reviewing the information on the depth of overburden, it appears that the soil thickness is sufficient in the lake to where grouting on the present shoreline should be effective. At this time, I do not believe that grouting at a higher elevation is necessary.

In summary, I recommend that we wait until the lake can be observed as to whether it is still leaking before more grouting is done.

Yours truly,

A handwritten signature in cursive script, appearing to read "Thomas J. Dean".

Thomas J. Dean, Geologist
Engineering Geology Section
Geology & Land Survey

cc: Don Ransey

END

DATE
FILMED

12-81

DTIC