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MISSOURI-KANSAS CITY DAM

RAY COUNTY DAM NO. C-21

RAY COUNTY, MISSOURI

NO 10238

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# PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY INSPECTION

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United States Army  
Corps of Engineers  
ST. LOUIS DISTRICT

St. Louis District

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

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A106 639	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Ray County Dam C-21 (MO 10238) Ray County, Missouri		5. TYPE OF REPORT & PERIOD COVERED Final Report.
7. AUTHOR(s) Black & Veatch, Consulting Engineers		8. CONTRACT OR GRANT NUMBER(s) DACW43-79-C-0040
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		12. REPORT DATE May 1979
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 1241		13. NUMBER OF PAGES Approximately 40
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for release; distribution unlimited Paul R. /Zaman Edwin R. /Burton Harry L. /Callahan		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) National Dam Safety Program. Ray County Dam Number C - 21 (MO 10238), Missouri - Kansas City Basin, Ray County, Missouri. Phase I Inspection Report.		
18. SUPPLEMENTARY NOTES		
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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# MISSOURI-KANSAS CITY BASIN

RAY COUNTY DAM NO. C - 21  
RAY COUNTY, MISSOURI  
MO 10238

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## PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY INSPECTION



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

**St. Louis District**

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

FOR: STATE OF MISSOURI

MAY 1979



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

IN REPLY REFER TO

SUBJECT: Ray County Dam No. C-21 Mo. ID. No. 10238  
Phase I Inspection Report

This report presents the results of field inspection and evaluation of Ray County Dam No. C-21. It was prepared under the National Program of Inspection of Non-Federal Dams.

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

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

**SIGNED**

SUBMITTED BY: \_\_\_\_\_

Chief, Engineering Division

09 MAY 1980

Date

**SIGNED**

APPROVED BY: \_\_\_\_\_

Colonel, CE, District Engineer

09 MAY 1980

Date

RAY COUNTY DAM NO. C-21

RAY COUNTY, MISSOURI

MISSOURI INVENTORY NO. 10238

PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH  
CONSULTING ENGINEERS  
KANSAS CITY, MISSOURI

UNDER DIRECTION OF  
ST. LOUIS DISTRICT CORPS OF ENGINEERS

FOR  
GOVERNOR OF MISSOURI

MAY 1979

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Ray County Dam No. C-21
State Located	Missouri
County Located	Ray County
Stream	Tributary to Willow Creek
Date of Inspection	17 May 1979

Ray County Dam No. C-21 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 a small size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers, failure would threaten the life and property of families in the town of Henrietta and would potentially cause damage to a road and the Atchison, Topeka, and Sante Fe Railroad within the estimated damage zone which extends approximately three miles downstream of the dam.

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 pass neither 50 nor 100 percent of the probable maximum flood without overtopping, but will pass both 25 percent of the probable maximum flood and the 100-year flood. The spillway design flood recommended by the guidelines is 50 to 100 percent of the probable maximum flood. Considering the small volume of water impounded and the downstream hazard, 50 percent of the probable maximum flood is the appropriate spillway design flood. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

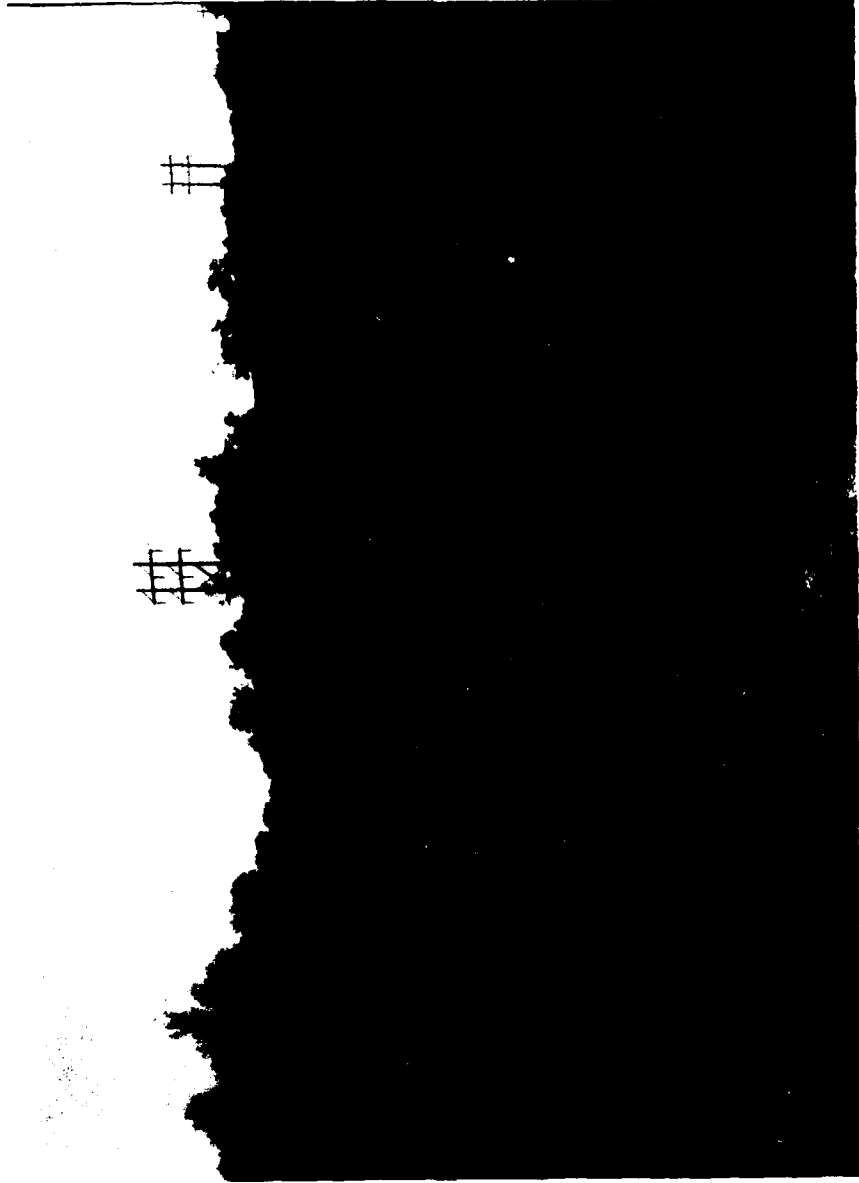
Deficiencies visually observed by the inspection team were seepage downstream of the abutments; erosion on the downstream berm, spillway floor, and left abutment; rutting on the dam crest; animal burrows in the embankment; and heavy grazing on the embankment.

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. A detailed report discussing each of these deficiencies is attached.

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Black & Veatch



OVERVIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM  
RAY COUNTY DAM NO. C-21

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## SECTION 1 - PROJECT INFORMATION

### 1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Ray County Dam No. C-21 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 Ray County Dam No. C-21, hereafter referred to in this report as Dam No. C-21, is an earthen structure located in south-central Ray County, Missouri on a tributary to Willow Creek. This structure was designed by the Soil Conservation Service (SCS) and was constructed under their supervision. The principal purpose for this dam is grade stabilization. Dam No. C-21 is an integral part of the Willow Creek Watershed Plan and is located on property owned by Mr. Jesse James, Route 2, Richmond, Missouri. The dam is 14 feet wide at the crest, 600 feet long and 32 feet high at the principal spillway. The dam has an emergency spillway located at the right abutment, and a principal spillway located near the center of the structure. The embankment has grass cover over the majority of the slopes, crest, and spillway.

(2) A grass-lined emergency spillway is located at the right abutment. It consists of a grass-lined approach channel and discharge channel. The spillway approach and discharge channels have trapezoidal cross-sections. The spillway is cut through natural material and is separated from the dam structure.

(3) A principal spillway consisting of a drop inlet with a 24-inch diameter riser, trash rack, and baffle plate, with an 18-inch discharge pipe, has been provided at this dam. An 8-inch pipe at the upstream portion of the riser, which has been blocked with a steel plate, was initially constructed to allow establishment of proper vegetal cover on the upstream face prior to the reservoir filling to the normal pool elevation (El.734.2). The 18-inch pipe discharges into a naturally eroded plunge pool before flowing to the main tributary channel to Willow Creek.

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

b. Location. The dam is located in south-central Ray 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 Richmond, Missouri in Section 5 of T51N, R27W.

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 small size category.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The Ray County Dam No. C-21 has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial, and commercial facilities, and to important public utilities, main highways, or railroads. For the Dam No. C-21 the estimated flood damage zone extends downstream for approximately three miles. Within the damage zone is the town of Henrietta, Missouri, one road and the Atchison, Topeka, and Santa Fe Railroad.

e. Ownership. The dam is owned and maintained by the Willow Creek Watershed Subdistrict, P.O. Box 380, Richmond, Missouri 64085. The structure and reservoir is located on property owned by Mr. Jesse James, Route 2, Richmond, Missouri 64085.

f. Purpose of Dam. The dam forms an 11.8-acre grade stabilization lake.

g. Design and Construction History. Data relating to the design and construction were made available by the Soil Conservation Service, Columbia, Missouri. The dam was constructed in 1971.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, and evaporation and flow through the uncontrolled principal spillway all combine to maintain a relatively stable water surface elevation.

i. Maintenance. The Willow Creek Watershed Subdistrict, P.O. Box 380, Richmond, Missouri 64085 is the group responsible for maintenance at this dam.

1.3 PERTINENT DATA

a. Drainage Area - 297 acres.

b. Discharge at Damsite.

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

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

(3) Estimated combined ungated spillway capacity at maximum pool elevation - 590 cfs (Probable Maximum Flood Pool El.742.3).

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

(1) Top of dam - 741.3 ± (see Plate 3)

(2) Principal spillway crest - 734.2

(3) Emergency spillway crest - 738.8

(4) Streambed at toe of dam - 710.0 ±

(5) Maximum tailwater - Unknown.

d. Reservoir.

(1) Length of maximum pool - 2,000 feet ±

(2) Length of normal pool - 1,800 feet ±

e. Storage (Acre-feet).

(1) Top of dam - 200

(2) Emergency spillway crest - 140

(3) Principal spillway crest - 83

(4) Design surcharge - 60

f. Reservoir Surface (Acres).

- (1) Top of dam - 22
- (2) Emergency spillway crest - 17.8
- (3) Principal spillway crest - 11.8

g. Dam.

- (1) Type - Earth embankment
- (2) Length - 600 feet
- (3) Height - 32 feet  $\pm$
- (4) Top width - 14 feet
- (5) Side slopes - upstream face 1.0 V on 2.5 H, downstream face varies from 1.0 V on 2.5 H to 1.0 V on 3.0 H (see Plate 4)
- (6) Zoning - None.
- (7) Impervious core - None.
- (8) Cutoff - Core trench, earthfill
- (9) Grout curtain - None.
- (10) Internal drainage system - None.

h. Diversion and Regulating Tunnel - None.

i. Emergency Spillway.

- (1) Type - Broad-crested weir with trapezoidal cross section.
- (2) Bottom width of channel - 26 feet.
- (3) Channel side slopes - Range from 1.0 V on 4.2 H to 1.0 V on 5.2 H
- (4) Crest elevation - 738.8 feet m.s.l.
- (5) Gates - None.

(6) Upstream channel - Not applicable.

(7) Downstream channel - Grass-lined, bermed channel and pasture near the toe of the downstream embankment slope.

j. Principal Spillway.

(1) Type - Corrugated metal pipe vertical inlet with trash rack and baffle plate.

(2) Crest elevation - 734.2

(3) Gates - None.

(4) Upstream channel - None.

(5) Discharge pipe - 18-inch diameter corrugated metal pipe with diaphragms.

(6) Downstream channel - Open channel comprised of clay and silt.

k. Regulating Outlets - None.

## SECTION 2 - ENGINEERING DATA

### 2.1 DESIGN

Design data were available in the form of construction logs "As Built" drawings, site geology and soils reports, and the "Willow Creek Watershed -Work Plan."

### 2.2 CONSTRUCTION

The dam was constructed in 1971 by Ira R. Thornton, 632 Forrest Smith Ave., Richmond, Missouri 64085. Construction log indicated that there was a problem with proper compaction of backfill around the discharge pipe beneath the embankment with several comments of 'very good job' on core and embankment fill compaction.

### 2.3 OPERATION

The maximum recorded loading on the dam is unknown.

### 2.4 GEOLOGY

Dam No. C-21 is located across a broad shallow valley formed in loess. The geology consists of the Kennebec, Knox, and Sibley Silt Loam soil series overlying shale bedrock of the Marmaton Group of the Pennsylvanian System. The Kennebec soil series consists of silt loam (ML) formed in alluvium on floodplains and gently sloping footslopes. The Knox soils are silt loams (ML) to very fine sandy loams (ML) formed in loess on ridge tops and side slopes. The Sibley Silt Loam series consists of silty clay loams (CL) and silt loams (ML) formed in loess on convex ridge tops and side slopes.

The foundation and abutments of the dam consist of silty clay (CL) silt (ML) derived from alluvium and loess. The bedrock contact is irregular and varies in depth below the original grade from 30 feet to 49 feet to 15 feet from the left to right abutments.

The downstream channel is formed in loess. No outcrops of bedrock were observed in the channel.

### 2.5 EVALUATION

a. Availability. Engineering data were obtained as noted in Section 2.1.

b. Adequacy. The engineering data available provides an adequate description and classification of subsurface materials at the dam site, emergency spillway, and borrow areas. The embankment materials for the dam were obtained primarily from the emergency spillway excavation and the borrow area from within the reservoir area. Embankment materials were fine-grained soils classified as silty clay (CL) and silt (ML).

Design slopes for the embankment must be obtained using previous experience by the SCS or other agencies' material classifications and generalized embankment and foundation conditions. The embankment contains a 10-foot wide berm on the upstream slope at approximate elevation 734.2 (construction record drawings) and at approximate elevation 719.2 (field survey) on the downstream slope. The effective slopes (constructed slope including berm) are approximately 3H to 1V for both the upstream and downstream slopes. The design slopes for Dam C-21 are consistent with the recommended slopes for small homogeneous earth fill dams on stable foundations as presented in USBR "Design of Small Dams", Second Edition - 1973, Table 18.

Engineering data were available from which to make an assessment of construction and operation of the facilities.

c. Validity. The available engineering data on the design, construction, and operation was determined to be valid.

## SECTION 3 - VISUAL INSPECTION

### 3.1 FINDINGS

a. General. A visual inspection of Dam No. C-21 was made on 17 May 1979. The inspection team included professional engineers with experience in dam design and construction, hydrology, hydraulic engineering, and geotechnical engineering. 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 that the dam is in generally good condition with the exception of the following items: Seepage of less than 1 gpm and clear in appearance was observed flowing through the right abutment near the discharge channel and discharge culvert. Water was observed standing downstream of the left abutment at the downstream end of the berm with no visible flow.

The dam is located within a pasture and grazing has taken place. Because of this, cattle paths and some areas of overgrazing on the embankment slopes have developed. Some minor erosion has occurred in areas of overgrazing and along the more well defined paths.

Erosion of approximately 1 foot in depth was observed on the downstream slope at the berm crest above the discharge culvert and the downstream embankment toe. Minor erosion was visible near the left abutment not greater than 1 foot in depth. The embankment soil is classified as ML-CL and has a high potential for erosion.

The grass slope protection on the upstream face is generally in good condition and appears adequate. There is no existing riprap on the embankment.

A vehicular path was observed on the dam's crest with one pothole. A few small animal burrows were found on the upstream face of the embankment. No evidence of sliding, cracking, settlement, or sinkholes was observed.

c. Appurtenant Structures. The inspection team observed the following items pertaining to appurtenant structures. The emergency spillway is located near the right abutment. The spillway and the approach and discharge channels are adequately grass-lined with only minor areas of erosion on the spillway floor. The emergency spillway will act as a broad-crested weir. The soils of the emergency spillway and berm are classified as ML-CL and have a high potential for erosion.

The principal spillway consisting of a drop inlet with trash rack and baffle plate appears to be in good condition. The discharge culvert is in generally good condition, although major portions were unobservable.

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

e. Downstream Channel. The downstream channel is an open channel comprised of clay and silt. The banks of the downstream channel are covered with brush and large trees.

### 3.2 EVALUATION

During the inspection there were deficiencies observed which warrant attention. None of these deficiencies should be considered in an emergency category, although, in order to continue to maintain this dam in good to excellent condition they should be rectified.

a. Heavy grazing of the dam by cattle has caused some paths to be developed and some localized areas to be overgrazed. Minor areas of erosion have developed as a result of this practice. The potential for increased erosion exists along cattle paths and overgrazed areas. Restrictions on cattle grazing should be enforced in order to prevent further problems. The areas of erosion should be re-vegetated.

b. The crest has been used as a vehicle crossing and as such two paths have been formed. The paths are void of grass cover and are potential starting points for erosion. A pothole with ponded water has formed in this path near the left end of the dam crest. The pothole should be filled with compacted soil and the crest should be crowned and re-vegetated.

c. A few small animal burrows were located on the upstream slope. Animal burrows can ultimately jeopardize the safety of an earthen structure if allowed to increase in number. The animal burrows should be filled and compacted under the supervision of an experienced engineer. The embankment should be monitored for evidence of additional animal burrowing.

d. Although it is unlikely that the seepage will become a problem in the foreseeable future it should be monitored regularly. An engineer experienced in earth dam design should be consulted for purposes of analyzing and designing control measures if the quality or quantity of seepage changes.

## SECTION 4 - OPERATIONAL PROCEDURES

### 4.1 PROCEDURES

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

### 4.2 MAINTENANCE OF DAM

Under terms of the Soil Conservation Service Watershed program for Willow Creek, Ray County, Missouri, maintenance for Dam No. C-21 is the responsibility of the Willow Creek Watershed Subdistrict, Richmond, Missouri.

Maintenance performed was unknown.

### 4.3 MAINTENANCE OF OPERATING FACILITIES

Maintenance performed was unknown.

### 4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

The inspection team is not aware of any existing warning system for this dam.

### 4.5 EVALUATION

The maintenance of the dam appears to be adequate for a structure of this type. Corrective measures as suggested elsewhere in this report should be implemented to keep this dam in its visibly good condition.

## SECTION 5 - HYDRAULIC/HYDROLOGIC

### 5.1 EVALUATION OF FEATURES

a. Design Data. Limited design data pertaining to hydrology and hydraulics were included in the design drawings. Independent calculations were, however, performed for the report in accordance with the referenced guidelines.

b. Experience Data. The drainage area and lake surface area were from drawings provided by the Soil Conservation Service based on their field surveys. The spillway and dam layouts are from surveys made during the inspection and available design documents.

c. Visual Observations.

(1) The emergency and principal spillways are in good condition. Discharge channels for both spillways are also in good condition.

(2) Facilities are not available which could serve to draw down the pool.

(3) An emergency spillway with a grass-lined discharge channel is located near the right abutment. Discharges from this appurtenance are unlikely to endanger the integrity of this dam. The dam is protected from emergency discharges through the spillway and channel by a grass-covered berm. Discharges reach a tributary to Willow Creek at an appreciable distance downstream from the dam and therefore should not pose any threat to the structure.

(4) A principal spillway with discharge pipe is located near the center of the dam.

d. Overtopping Potential. The emergency and principal spillways discharging simultaneously will not pass the probable maximum flood without overtopping the dam. 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 that are reasonably possible in the region. The spillways will pass 25 percent of the probable maximum flood and the 100-year flood without overtopping the dam. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of small size should pass 50 to 100 percent of the probable maximum flood. Considering the small volume of water impounded and the downstream hazard, 50 percent of the probable maximum flood is the appropriate spillway design flood. The portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be

900 cfs of the total discharge from the reservoir of 1,360 cfs. The estimated duration of overtopping is 3.4 hours with a maximum height of 0.6 feet. Failure of the upstream water impoundment shown on the USGS map should not have a significant impact on the hydrologic and hydraulic analyses. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 2,140 cfs of the total discharge from the reservoir of 2,730 cfs. The estimated duration of overtopping is 5.8 hours with a maximum height of 1.0 feet. There is evidence that the soils observed as characteristic of the embankment crest, the emergency spillway, and the berm are susceptible to erosion. Although the inspection team found no evidence of overtopping of the embankment, prolonged overtopping of the embankment is anticipated to cause erosion which could lead to failure.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately three miles downstream of the dam. The town of Henrietta, Missouri, a road, and the Atchison, Topeka, and Santa Fe Railroad are downstream of the dam which could be severely damaged and lives could be lost should failure of the dam occur. A water treatment plant is located about 1.5 miles downstream of this structure which could conceivably be damaged in the event of a dam failure.

## 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. Available design data included the Project Engineer's Recommendations, summary report of the geologic investigation and soil classification tests.

Available construction data included "as-built" construction drawings.

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.

Based upon material classification and soil boring data, it is anticipated that the stability of the dam exceeds the suggested factor of safety as given in Table 4 of the Guidelines. The slopes of the dam are consistent with recommended slopes for small homogeneous earthfill dams on stable foundations as given in the USBR "Design of Small Dams".

c. Operating Records. No operational records exist.

d. Post Construction Changes. No known post construction changes.

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

Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available. It is the opinion of the reviewers that an earthquake consistent with Seismic Zone 1 intensities will not cause serious structural damage to this dam.

## SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

### 7.1 DAM ASSESSMENT

a. Safety. Several items noted during the visual inspection by the inspection team which should be monitored or controlled are seepage, overgrazing and extensiveness of cattle path development, animal burrows and erosion/rutting of dam crest.

b. Adequacy of Information. The conclusions in this report are based on performance history, visual conditions, and the available engineering design data. 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 to implement remedial measures recommended in paragraph 7.2b as soon as possible. The item recommended in paragraph 7.2.a should be pursued promptly.

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

e. Seismic Stability. This dam is located in Seismic Zone I. The dam is considered to be adequately designed and constructed to withstand an earthquake normally expected for the area.

### 7.2 REMEDIAL MEASURES

a. Alternatives. The principal and emergency spillways, acting together, have the capacity to pass 25 percent of the probable maximum flood without overtopping the dam. In order to pass 50 to 100 percent of the probable maximum flood as required by the Recommended Guidelines, the spillway sizes and/or height of dam would need to be increased. In either case, the spillway should be protected to prevent erosion.

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

(1) Measures should be implemented to maintain control of burrowing animals. Existing burrows should be repaired under the direction of an engineer experienced in construction of earth dams.

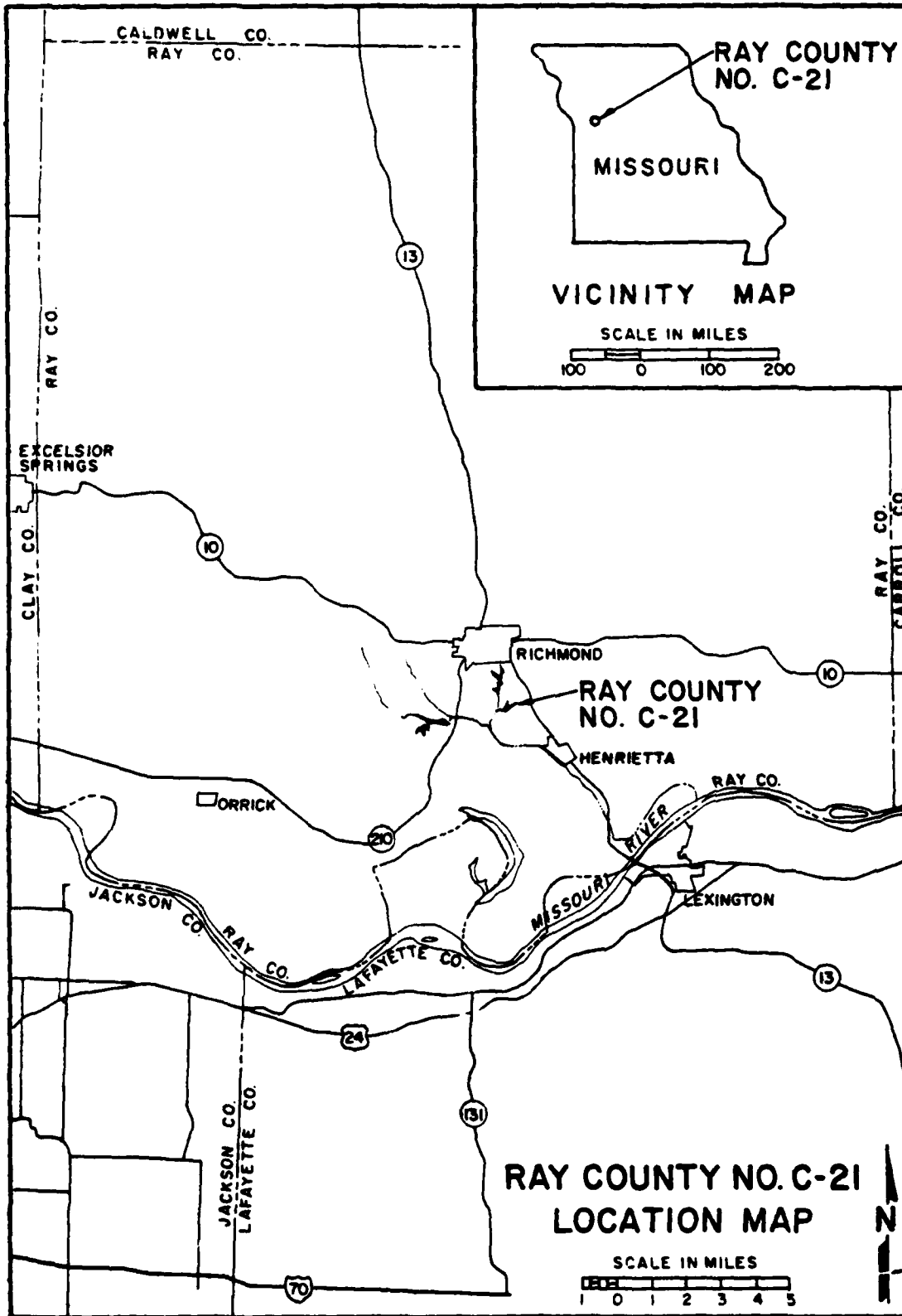
(2) Cattle grazing should be restricted on this structure. The areas where overgrazing has resulted in erosion should be re-vegetated.

(3) Seepage should be monitored on a regular interval and records maintained documenting discharge and visible condition of the seepage. In the event quality or quantity conditions change, an engineer experienced in earth dam design should be consulted for purposes of analyzing and designing control measures.

(4) The pothole near the left end of the dam crest should be filled with compacted soil. The rutting on the crest should be repaired by crowning and re-vegetation.

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

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



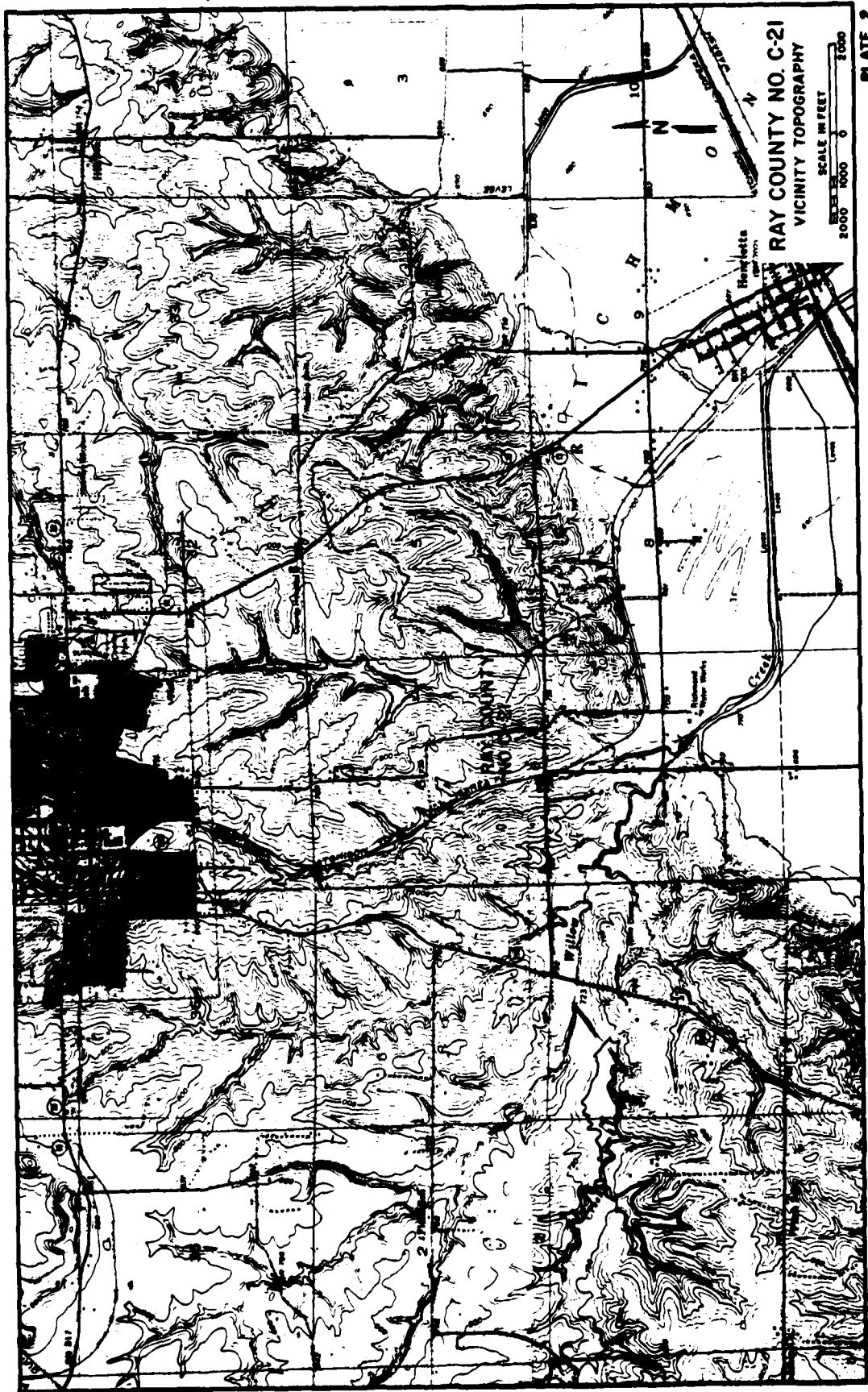
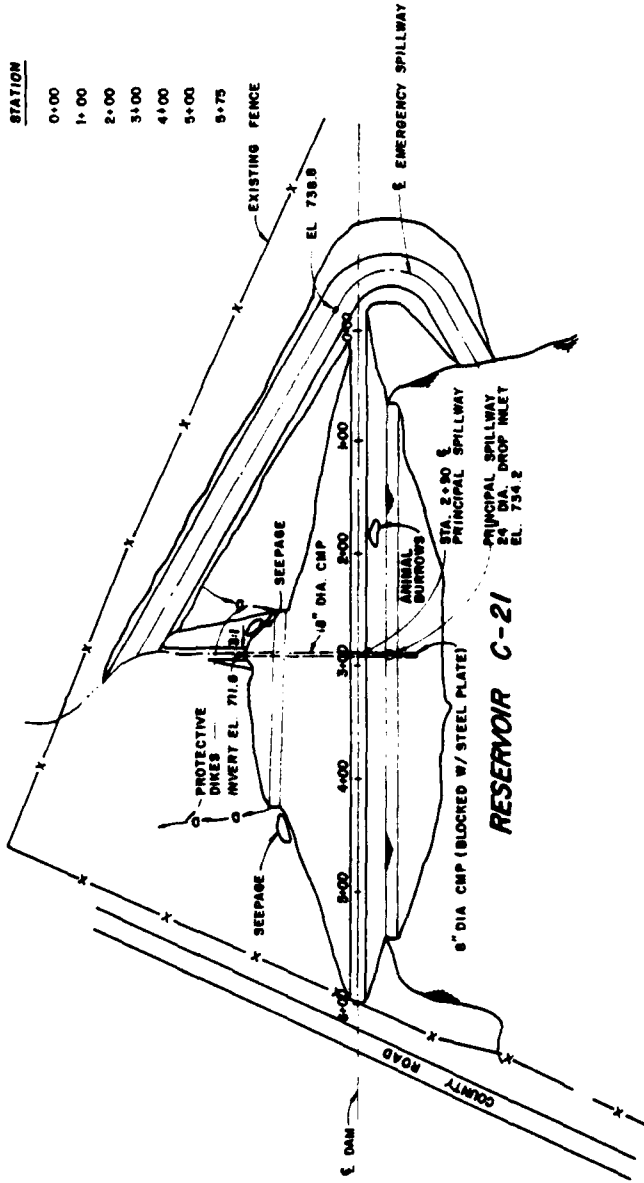


PLATE 2

STATION	ELEVATION
0+00	741.2
1+00	741.3
2+00	741.6
3+00	741.5
4+00	741.3
5+00	741.2
5+75	740.9

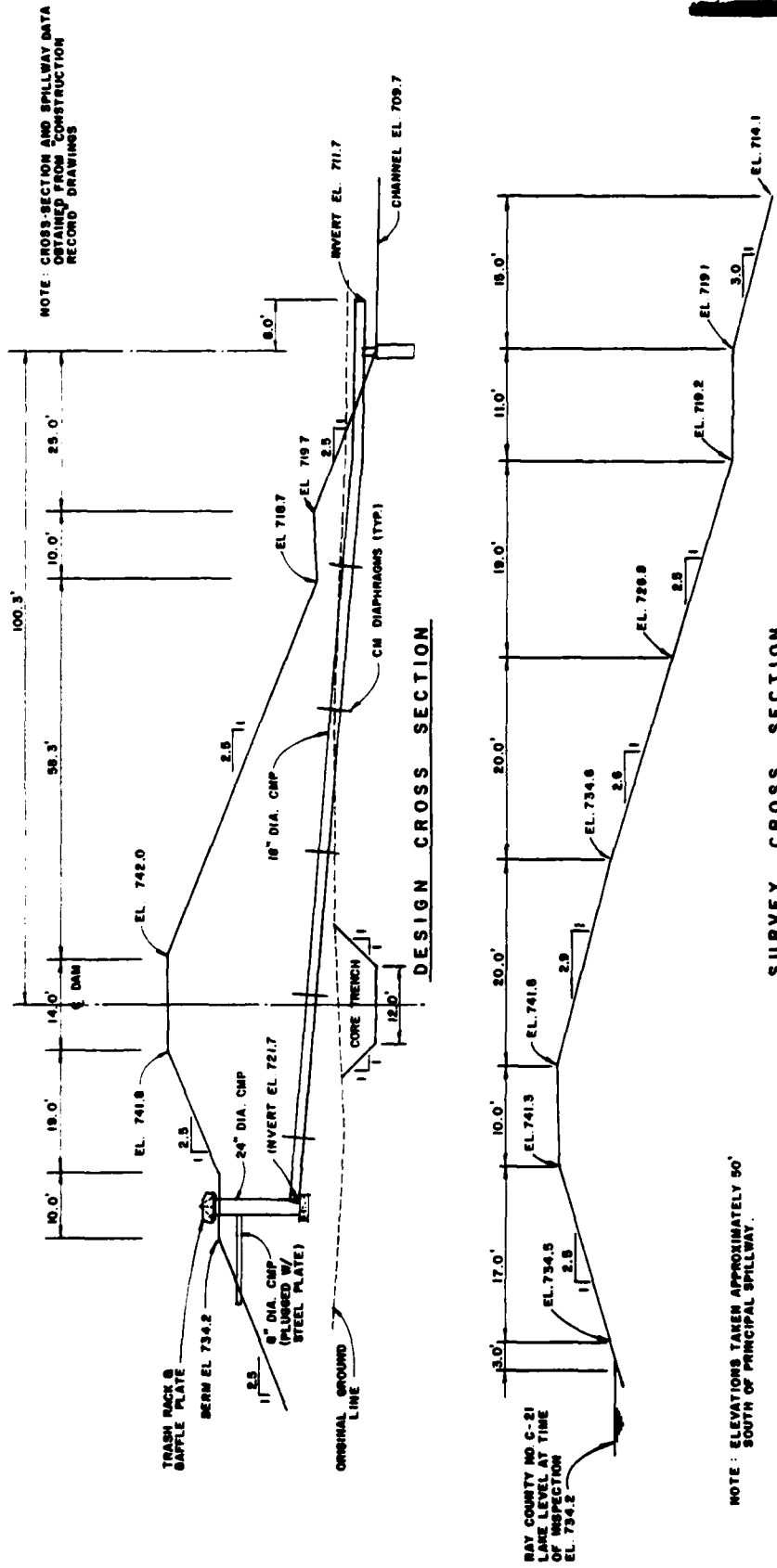


**RESERVOIR C-21**

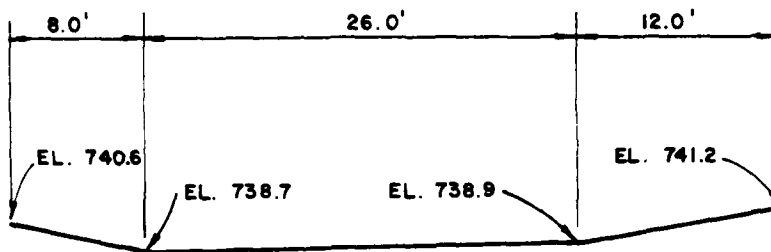
NOTE: LAYOUT DATA OBTAINED FROM  
 CONSTRUCTION RECORD DATA  
 CONTAINING ELEVATION DATA  
 OBTAINED FROM FIELD SURVEY



**RAY COUNTY NO. C-21  
 PLAN**



**RAY COUNTY NO. C-21  
TYPICAL SECTIONS**

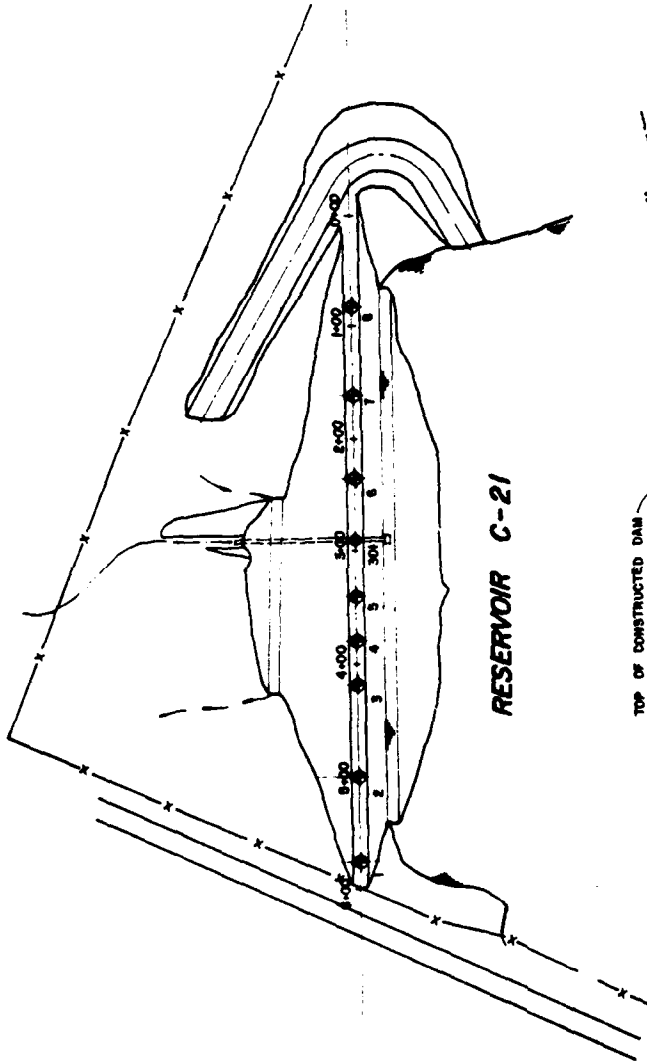


NOTE: CROSS-SECTION TAKEN APPROXIMATELY  
50' DOWNSTREAM OF THE  $\text{C}$  OF THE DAM.

RAY COUNTY NO. C-21  
EMERGENCY SPILLWAY SECTION

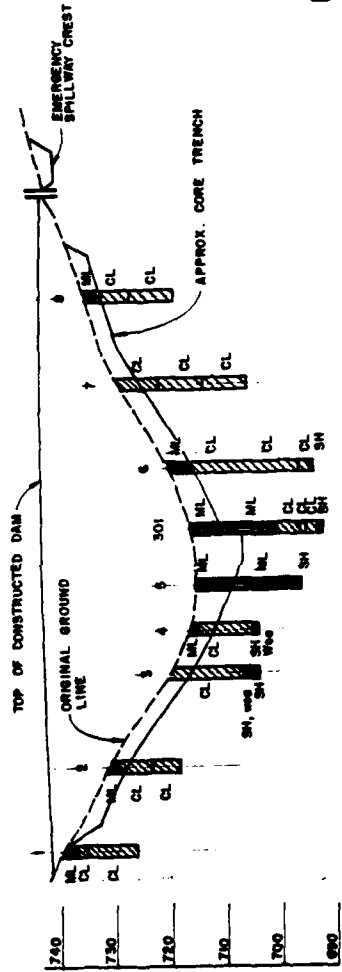
PLATE 5

NOTE: OBTAINED FROM "CONSTRUCTION RECORD" DRAWINGS

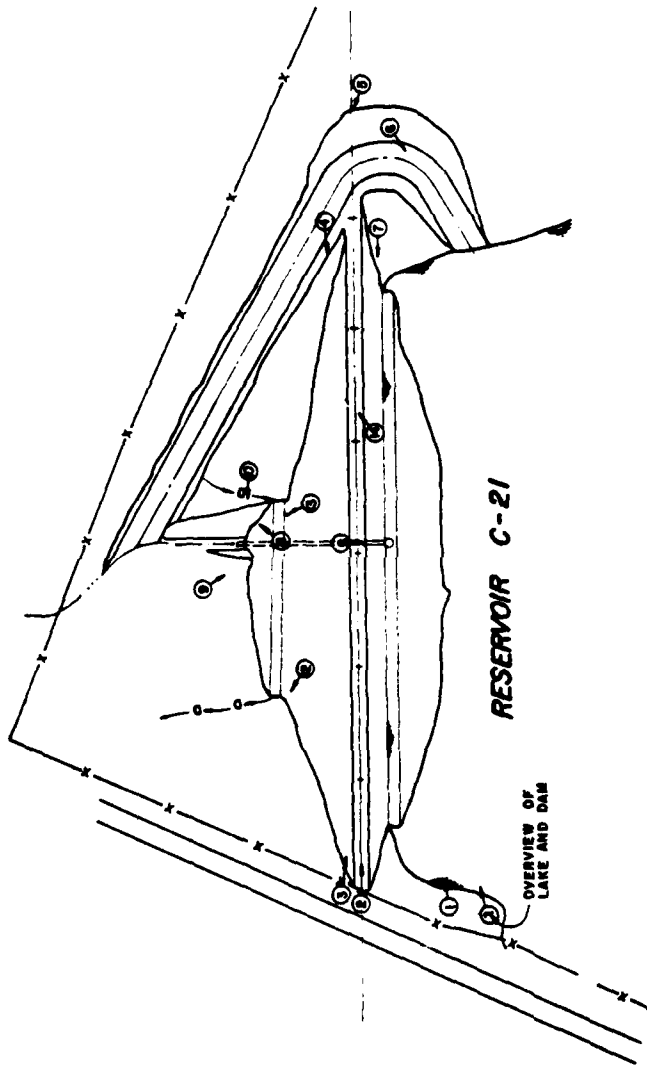


LEGEND

- ◆ BORING HOLE
- ML SLTS WITH LIQUID LIMIT OF 50 OR LESS
- CL CLAYS WITH LIQUID LIMIT OF 50 OR LESS
- SH SANDS WITH LIQUID LIMIT ABOVE 50
- SH, WEQ WEATHERED SANDS WITH LIQUID LIMIT ABOVE 50



RAY COUNTY NO. C-21  
BORING PLAN  
PLATE 6



RESERVOIR C-21

OVERVIEW OF LAKE AND DAM

LEGEND  
① PHOTO LOCATION AND DIRECTION

RAY COUNTY NO. C-21  
PHOTO INDEX

PLATE

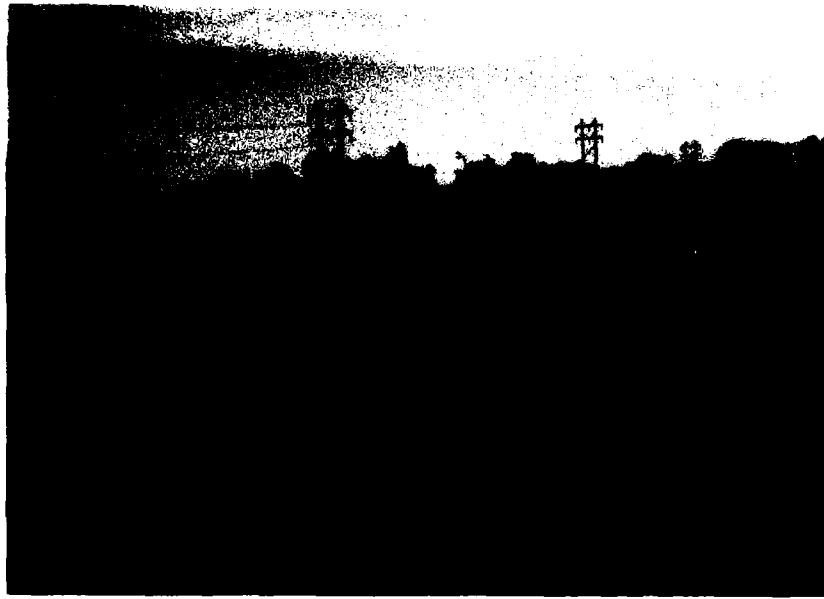


PHOTO 1: UPSTREAM FACE OF DAM

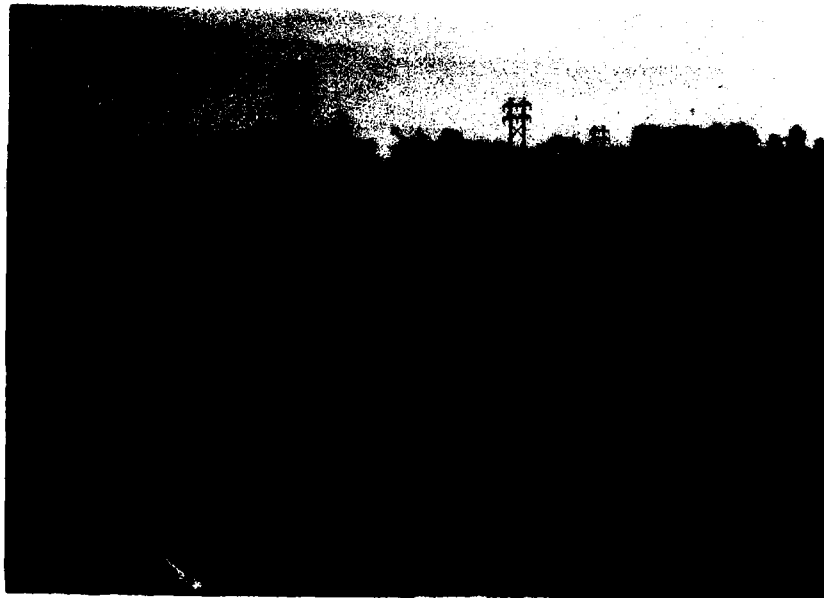


PHOTO 2: CREST OF DAM



PHOTO 3: DOWNSTREAM FACE OF DAM LOOKING TOWARD EMERGENCY SPILLWAY



PHOTO 4: DOWNSTREAM FACE OF DAM LOOKING FROM EMERGENCY SPILLWAY



PHOTO 5: EMERGENCY SPILLWAY LOOKING DOWNSTREAM FROM RIGHT ABUTMENT



PHOTO 6: EMERGENCY SPILLWAY LOOKING UPSTREAM FROM CREST



PHOTO 7: UPSTREAM BENCH WITH PRINCIPAL SPILLWAY INLET

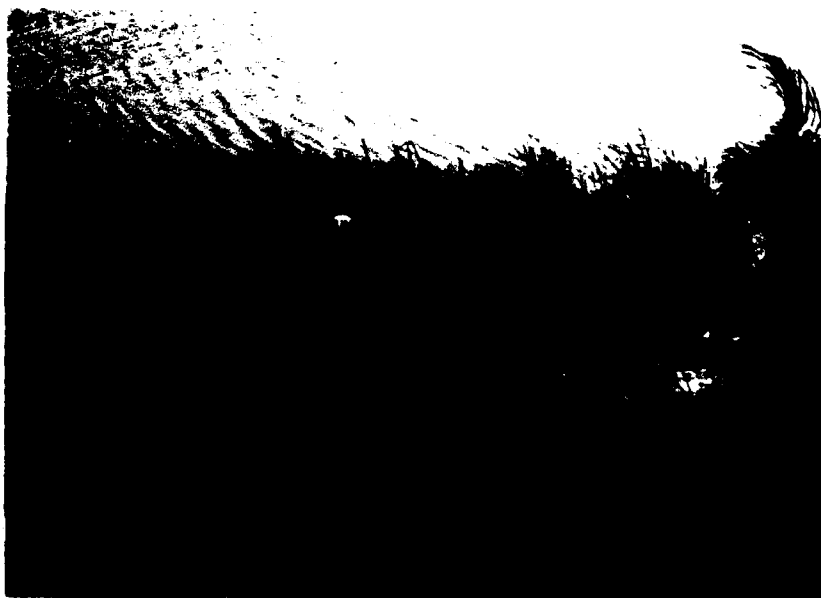


PHOTO 8: PRINCIPAL SPILLWAY INLET

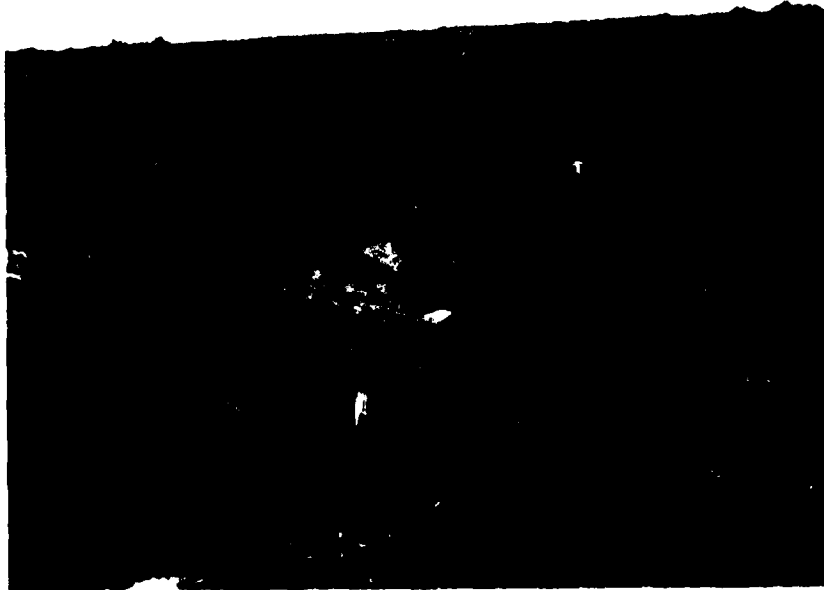


PHOTO 9: DISCHARGE PIPE, PRINCIPAL SPILLWAY



PHOTO 10: EROSION AT TOE OF DAM NEAR DISCHARGE PIPE



PHOTO 11: SEEPAGE AREA AT RIGHT OF DISCHARGE PIPE



PHOTO 12: SEEPAGE AREA AT LEFT OF DISCHARGE PIPE BELOW TOE



PHOTO 13: DISCHARGE PIPE AND CHANNEL



PHOTO 14: SMALL ANIMAL BURROWS IN EMBANKMENT

APPENDIX A  
HYDROLOGIC COMPUTATIONS

### HYDROLOGIC COMPUTATIONS

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

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

200 square mile, 24 hour rainfall inches	- 24.5
10 square mile, 6 hour percent of 24 hour 200 square mile rainfall	- 101%
10 square mile, 12 hour percent of 24 hour 200 square mile rainfall	- 120%
10 square mile, 24 hour percent of 24 hour 200 square mile, rainfall	- 130%

b. Drainage area = 297 acres.

c. Time of concentration:

$$T_c = (1.67) L$$

$$L = \frac{\ell^{0.8} (S+1)^{0.7}}{1,900 Y^{0.5}}$$

L = lag in hours

$\ell$  = hydraulic length of watershed in feet

$$S = \frac{1,000}{CN} - 10 \text{ (where CN is the retardance factor and is equivalent to the runoff curve number)}$$

Y = average watershed land slope in percent

$$T_c = 1.1 \text{ hours (2).}$$

d. Losses were determined in accordance with SCS methods for determining runoff using a curve number of 85 and antecedent moisture condition III. The hydrologic soil group in the basin was B.

e. The soil associations in this watershed are mainly Knox and Marshall (3)

2. Principal spillway release rates are based on the weir and pipe flow equations.

Broad-crested weir equation:

$Q = CLH^{1.5}$  ( $C = 3.33$ ,  $L = \pi d = 6.28$  feet,  $H$  is the head on weir).

Pipe-flow equation:

$Q = Ca(2gh)^{0.5}$  ( $C = 0.313$ ,  $a = \pi d^2/4 = 1.77$  ft<sup>2</sup>,  $g = 32.2$  ft/sec<sup>2</sup>,  
 $h$  = difference in reservoir surface elevation and downstream culvert discharge outlet).

Emergency spillway releases are based upon calculations of critical depths of flow at the crest. Reservoir elevations corresponding to given spillway release rates were calculated by adding to the critical depth,  $d_c$ ; the velocity head,  $v^2/2g$ ; and the friction head,  $h_f$ . (4)

Discharge rates over the top of the dam are also based on the broad-crested weir equation:

$Q = CLH^{1.5}$  ( $C = 3.1$ ,  $L = 700$  feet).

3. The elevation-storage relationship above normal pool elevation was constructed by planimetering the area enclosed within each contour above normal pool. Storage at various elevations was computed utilizing the conic method for computation of reservoir volume provided in HEC-1(1).

## BIBLIOGRAPHY

- (1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Davis, California.
- (2) U.S. Department of Agriculture, Soil Conservation Service, SCS National Engineering Handbook, Section 4, Hydrology, August, 1975.
- (3) Soil and Water Conservation District of Ray County, Watershed Work Plan Willow Creek Watershed, Ray County, Missouri, November 1, 1965.
- (4) U.S. Department of Agriculture, Soil Conservation Service, Engineering Division, Hydraulics of Broad-Crested Spillways, Technical Release No. 39, Design Unit, May, 1968.



.....  
 FLOOD HYDROGRAPH CKAGE (HEC-1)  
 DAM SAFETY VERSI. JULY 1978  
 LAST MODIFICATION 26 FEB 79  
 .....

RUN DATE 04/21/80.  
 TIME 13:28.00.

MISSOURI DAM INSPECTION PROGRAM  
 ST LOUIS DISTRICT US ARMY CORPS OF ENGINEERS  
 RAY COUNTY NO C-21

NO NHR NMIN IDAY IMR IMIN METRC IPLT IPRT INSTAN  
 240 0 6 0 0 0 0 0 0 0 0  
 JOPER NWT LROPT TRACE  
 5 9 0 0

MULTI-PLAN ANALYSES TO BE PERFORMED  
 NPLAN= 1 NRTIO= 4 LRTIO= 1  
 RTIOS= .20 .25 .50 1.00

SUB-AREA RUNOFF COMPUTATION

24 HR PHF INFLOW C-21

ISTAO 1 ICOMP 0 IEGON 0 ITAPE 0 JPLT 0 JPRY 3 IMAE ISTAGE I AUTO  
 0 0 0 0 0 1 0 0 0

HYDROGRAPH DATA  
 INYDG IUNG TAREA SNAP TRSDA TRSPC RATIO ISNOV ISAME LOCAL  
 1 2 .46 0.00 .46 1.00 0.000 0 0 0 0

PRECIP DATA  
 SPFE PHS R6 R12 R24 R48 R72 R96  
 0.00 24.50 101.00 120.00 130.00 0.00 0.00 0.00

LOSS DATA  
 LROPT STRKR OLTKR RTIOE ERAIN STRKS RTIOK STRLE CNSLC ALSMK RTIMP  
 0 0.00 0.00 1.00 0.00 0.00 1.00 -1.00 -85.00 0.00 0.00

CURVE NO = 05.00 WETNESS = 1.00 EFFECT CN = 05.00

UNIT HYDROGRAPH DATA  
 TC= 0.00 LAG= .56

RECESSION DATA  
 STRTS= 0.00 QNCNSW= 0.00 RTIOR= 1.00

UNIT HYDROGRAPH 35 END OF PERIOD ORIGINATES, TC= 0.00 HOURS, LAG= .66 VOL= 1.00  
 18. 54. 108. 185. 258. 299. 312. 305. 276. 241.  
 19. 116. 92. 75. 60. 47. 38. 30. 24.  
 20. 12. 9. 6. 5. 4. 3.  
 21. 1. 0. 0. 0. 0. 0. 0. 0.

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ..... INITIAL VALUE 734.20 SPILLWAY CREST 734.20 TOP OF DAM 741.30  
 STORAGE 0. OUTFLOW 0. 193.  
 ELEVATION 740.64 741.29 741.85 742.29  
 RESERVOIR STORAGE AC-FT 92. 103. 114. 122.  
 MAXIMUM DEPTH OVER DAM 0.00 0.00 .55 .99  
 MAXIMUM STORAGE AC-FT 92. 103. 114. 122.  
 MAXIMUM OUTFLOW CFS 193. 316. 1356. 2728.  
 DURATION OVER TOP HOURS 0:00 0:00 3:40 5:00  
 TIME OF MAX OUTFLOW HOURS 17:20 17:20 16:30 16:30  
 TIME OF FAILURE HOURS 0:00 0:00 0:00 0:00

RATIO OF PNF	MAXIMUM RESERVOIR ELEVATION M.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	740.64	0.00	92.	193.	0:00	17:20	0:00
.25	741.29	0.00	103.	316.	0:00	17:20	0:00
.50	741.85	.55	114.	1356.	3:40	16:30	0:00
1.00	742.29	.99	122.	2728.	5:00	16:30	0:00

DATE  
ILMED  
— 8