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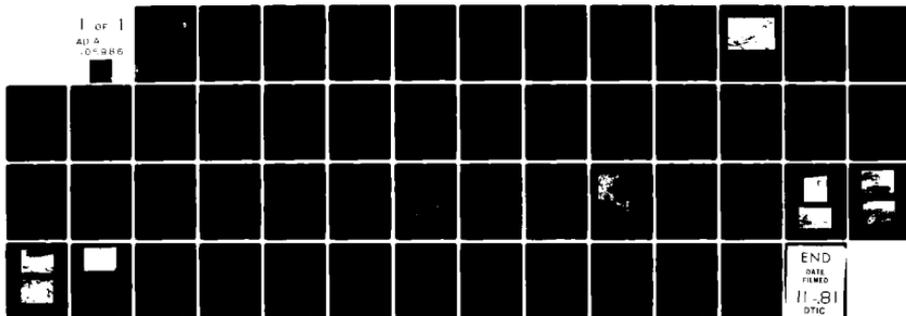
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WASHINGTON COUNTY, MISSOURI
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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION



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

St. Louis District

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

FOR: STATE OF MISSOURI

SEPTEMBER 1980

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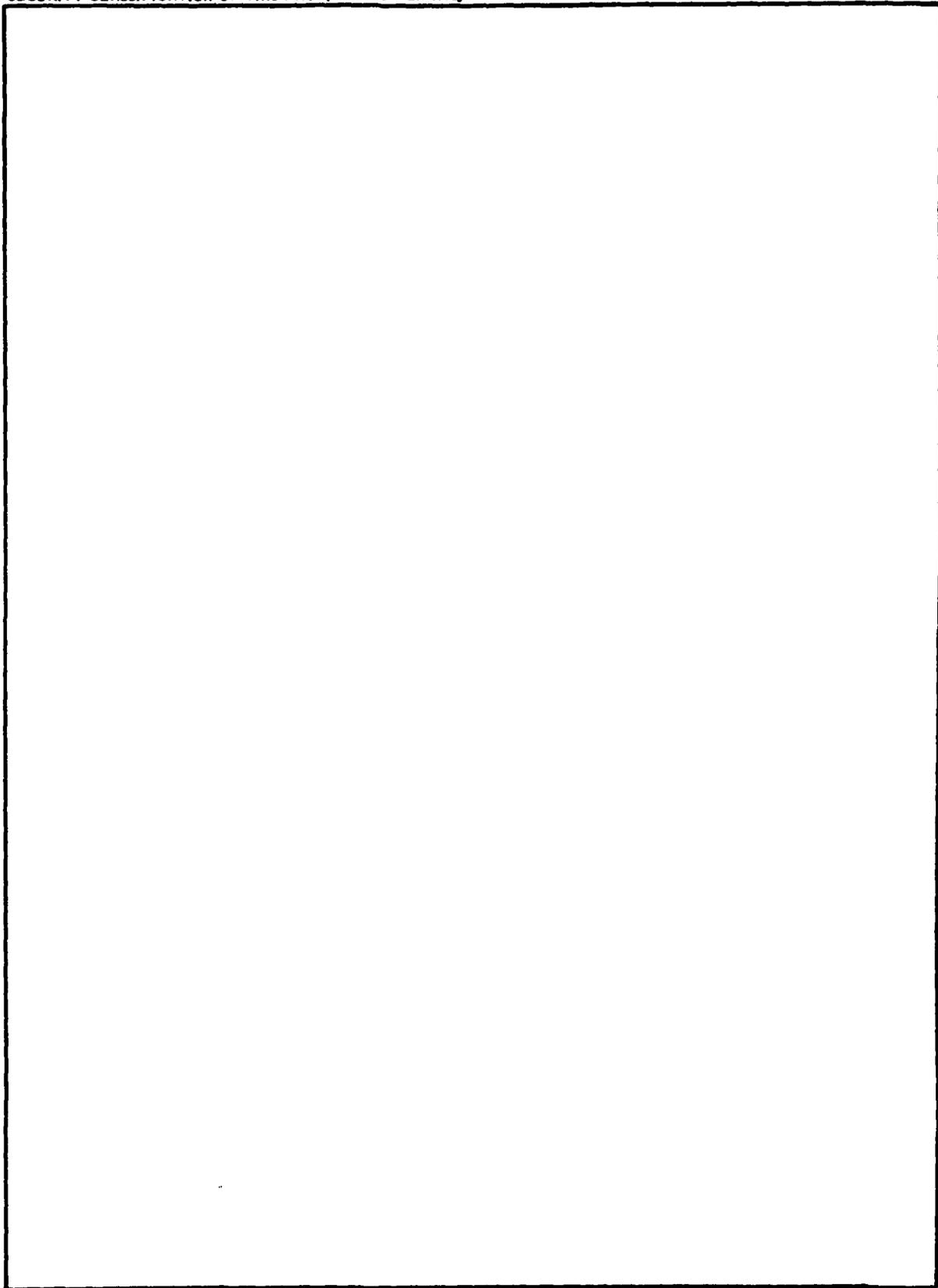
REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A165 986	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Lonedell Lake Dam (MO 31395) Franklin County, Missouri		5. TYPE OF REPORT & PERIOD COVERED Final Report.
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Woodward-Clyde Consultants	8. CONTRACT OR GRANT NUMBER(s) DACW43-80-C-0066	
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 September 1980
		13. NUMBER OF PAGES Approximately 40
14. MONITORING National Dam Safety Program. Lonedell Lake Dam (MO 31395). Mississippi-Kaskas- kia-St. Louis Basin, Washington County, Missouri. Phase I Inspection Report.		15. SECURITY CLASS. (of this report) UNCLASSIFIED
16. DISTRIBUTION Approved for release; distribution unlimited.		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEYWORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
 210 TUCKER BOULEVARD, NORTH
 ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

SUBJECT: Lonedell Lake Dam MO 31395

This report presents the results of field inspection and evaluation of the Lonedell Lake Dam. It was prepared under the National Program of Inspection of Non-Federal Dams.

The inspection results indicate problems with the spillway discharge channel which runs along the toe of the dam. The encroachment of the discharge channel on the toe of the right half of the dam could lead to additional erosion and slope failures. This in turn would adversely affect the stability of the dam.

SIGNED

SUBMITTED BY:

Chief, Engineering Division

24 SEP 1980

Date

APPROVED BY:

Colonel, CE, District Engineer

SIGNED

24 SEP 1980

Date

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LONEDELL LAKE DAM
Franklin County, Missouri
Missouri Inventory No. 31395

Phase I Inspection Report
National Dam Safety Program

Prepared by

Woodward-Clyde Consultants
Chicago, Illinois

Under Direction of
St Louis District, Corps of Engineers

for
Governor of Missouri
September 1980

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D. C., 20314. The purpose of a Phase I investigation is not to provide a complete evaluation of the safety of the structure nor to provide a guarantee on its future integrity. Rather the purpose of the program is to identify potentially hazardous conditions to the extent they can be identified by a visual examination. The assessment of the general condition of the dam is based upon available data (if any) and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies. In view of the limited nature of the Phase I studies no assurance can be given that all deficiencies have been identified.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with any data which may be available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action removes the normal load on the structure, as well as the reservoir head along with seepage pressures, and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, so that corrective action can be taken. Likewise continued care and maintenance are necessary to minimize the possibility of development of unsafe conditions.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Lonedell Lake Dam
State Located	Missouri
County Located	Franklin
Stream	Unnamed Tributary of Tyrey Creek
Date of Inspection	2 June 1980

Lonedell Lake Dam, Missouri Inventory Number 31395, was inspected by Richard Berggreen (engineering geologist), David Hendron (geotechnical engineer), and Sean Tseng (hydrologist).

The dam inspection was made following the guidelines presented in the "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines represent a consensus of the engineering profession. They are intended to provide an expeditious identification, based on available data and a visual inspection of those dams which may pose hazards to human life or property. In view of the limited nature of the study, no assurance can be given that all deficiencies have been identified.

The St Louis District, Corps of Engineers, has classified this dam as a high hazard; we concur with this classification. The estimated damage zone extends approximately 4 mi downstream of the dam. A series of three dams and lakes surrounded by vacation homes and permanent residences are located within this damage zone. The loss of life and property could be large in the event of overtopping and failure of the dam.

The dam is classified intermediate size based on its 56 ft height and its storage capacity of 191 ac-ft.

Our inspection and evaluation indicate the dam is in generally fair condition. Several small and one moderate size landslides were identified on the south side of the downstream slope of the dam. Erosion at the toe of the dam by encroachment of the discharge channel could cause additional slope failures in this area.

The spillway discharge capacity is calculated at $1403 \text{ ft}^3/\text{sec}$. Hydrologic analysis including storage capacity, indicates the dam will not be overtopped by a flood with 1 percent probability-of-occurrence (100-year flood) and the spillway will pass floods up to 85 percent of the Probable Maximum Flood (PMF) without overtopping the dam. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the site region.

It is recommended that the following remedial measures be implemented and additional studies be made for the facilities at Lonedell Lake Dam:

1. Realignment of the discharge channel to prevent erosion at the toe of the dam. The discharge channel may also require erosion protection to prevent lateral migration of the channel toward the toe of the dam.
2. Implementation of a periodic inspection program for the dam and appurtenant structures to identify evidence of instability in the dam, such as slumping or landslides, and increases in the amount of seepage flow or turbidity of the seepage water from the toe of the dam.
3. Evaluation of the erodibility of the spillway under high-velocity flow induced by a flood of 85 percent of PMF, which is the spillway capacity rating.
4. Performance of static and seismic stability analyses for this dam. These analyses should specifically include an evaluation of the moderate-size landslide on the downstream face of the embankment and its impact on the structural stability of the dam.
5. Assessment of the practicality of establishing a warning system for advising downstream residents, should potentially hazardous conditions develop during periods of heavy precipitation.

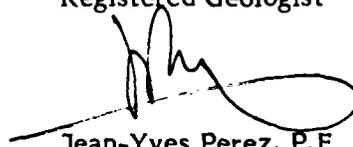
The analyses and remedial measures should be performed by an engineer experienced in the construction and maintenance of earth dams.

It is recommended the owner takes action on these recommendations in the near future to preclude deterioration which could lead to the development of unsafe conditions at this facility.

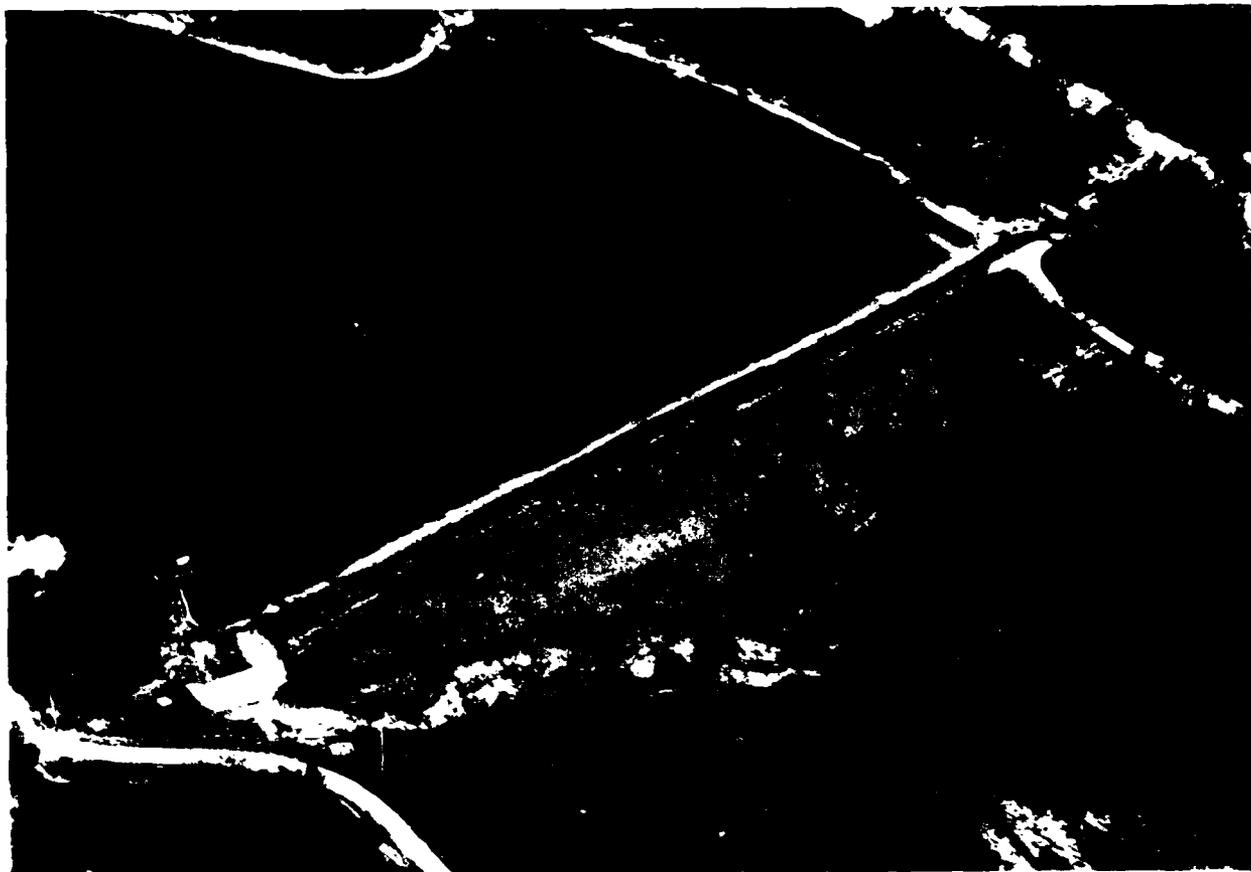
WOODWARD-CLYDE CONSULTANTS



Richard G. Berggreen
Registered Geologist



Jean-Yves Perez, P.E.
Vice President



OVERVIEW
LONEDELL LAKE DAM

MISSOURI INVENTORY NUMBER 31395

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
LONEDELL LAKE DAM - INVENTORY NO. 31395

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2.	Drainage Basin and Site Topography
3.	Dam and Spillway Cross-Sections and Plan
4.	Regional Geologic Map

APPENDICES

A	Figure A-1: Photo Location Sketch
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Photographs

1. Wave cut erosion upstream edge of Lonedell Lake Dam. Looking south.
2. Spillway weir and concrete apron. Looking north.
3. Erosion of downstream edge of spillway concrete apron. Looking north-west.
4. Erosion at toe of dam where riprap diverts discharge channel. Looking south.
5. Personnel outlining scarp of 100 ft wide landslide on face of dam. Looking southwest. Note willow tree and water weeds from seepage at toe of slide.
6. Seepage from base of tree at toe of landslide in Photo 5.
7. Drainage pipe at toe of Lonedell Dam.

B	Hydraulic/Hydrologic Data and Analyses
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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
LONEDELL LAKE DAM, INVENTORY NO. 31395

SECTION I
PROJECT INFORMATION

1.1 General

- a. **Authority.** The National Dam Inspection Act, Public Law 92-367, provides for a national inventory and inspection of dams throughout the United States, Pursuant to the above, an inspection was conducted of the Lonedell Lake Dam, Missouri Inventory Number 31395.

- b. **Purpose of Inspection.** "The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property... The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection determine any need for emergency measures and conclude if additional studies, investigations and analyses are necessary and warranted. (Chapter 3, Recommended Guidelines for Safety Inspection of Dams).

- c. **Evaluation criteria.** The criteria used to evaluate the dam were established in the "Recommended Guidelines for Safety Inspection of Dams", "Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188", Engineering and Design National Program for Inspection of Non-Federal Dams, prepared by the Office of Chief of Engineers, Department of the Army, and "Hydrologic/Hydraulic Standards Phase I Safety Inspection of Non-Federal Dams" prepared by the St Louis District, Corps of Engineers (SLD). 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. Lonedell Lake Dam is an earth dam (Photo 1). The spillway, located at the right abutment (as the observer faces downstream), consists of a trapezoidal, concrete-lined weir (Photo 2). The spillway is approximately 54 ft wide at the elevation of the dam crest. The crest of the spillway is approximately 5 ft below the lowest point surveyed on the dam crest. An 8 in. diameter, cast iron pipe is located at the toe of the dam, and may have been designed as a low level outlet. However, the valve could not be activated during the inspection and did not appear to have been activated in the recent past. It is considered inoperative. No control structures exist at the spillway for regulating flows.
- b. Location. The dam is located approximately 3 mi north of the town of Richwoods in Franklin County, Missouri, on a tributary of Tyrey Creek. It can be found on the USGS Richwoods NE, 7.5 minute quadrangle map (advance copy), Section 17, T40N, R2E (Fig. 1).
- c. Size. The dam is classified intermediate size due to its approximately 56 ft height and its storage capacity of 191 ac-ft.
- d. Hazard classification. SLD has classified the dam as a high hazard dam; we concur with this classification. The estimated damaged zone extends approximately 4 mi downstream of the dam. Within this damage zone are three earth dams, MO 30557, MO 30555, MO 30554 and many dwellings. Loss of life and property could be large in the event of overtopping and failure of this dam.
- e. Ownership. We understand the dam is owned by Lonedell Lakes Residents Association, P.O. Box 100, Lonedell, Missouri 63063. Correspondence should be addressed to the attention of Mr Floyd Montgomery.
- f. Purpose of dam. The reservoir is used for recreation purposes.
- g. Design and construction history. No design or construction reports were found for Lonedell Lake Dam.

Mr Jack Rogers, Vice President of the Residents Association indicated the dam for Lonedell Lake was started in 1971 and completed in 1972. Due to the small drainage basin, the lake took nearly 3 years to fill. The owner of the property when the dam was built, Mr Jack Patrick, is now deceased.

- h. Normal operating procedures. No operating records were found. Flood flows pass over the uncontrolled spillway at the right abutment. The maintenance man (name not available) for the Residents Association indicated he has never operated the low level outlet at the toe of the dam.

1.3 Pertinent Data

- a. Drainage area. approximately .28 mi²

- b. Discharge at damsite.

Maximum known flood at damsite	Unknown
Warm water outlet at pool elevation	N/A
Diversion tunnel low pool outlet at pool elevation	N/A
Diversion tunnel outlet at pool elevation	N/A
Gated spillway capacity at pool elevation	N/A
Gated spillway capacity at maximum pool elevation	N/A
Ungated spillway capacity at maximum pool elevation	1403 ft ³ /sec
Total spillway capacity at maximum pool elevation	1403 ft ³ /sec

- c. Elevation (ft above MSL).

Top of dam	827.3 to 829.4
Maximum pool-design surcharge	N/A
Full flood control pool	N/A
Recreation pool	822.3
Spillway crest (gated)	N/A
Upstream portal invert diversion tunnel	N/A
Downstream portal invert diversion tunnel	N/A
Streambed at centerline of dam	Unknown
Maximum tailwater	N/A
Toe of dam at maximum section	773.7

d. Reservoir.

Length of maximum pool	approximately 1700 ft
Length of recreation pool	approximately 1650 ft
Length of flood control pool	N/A

e. Storage (acre-feet).

Recreation pool	136
Flood control pool	N/A
Design surcharge	N/A
Top of dam	191

f. Reservoir surface (acres).

Top of dam	approximately 12.6
Maximum pool	approximately 12.6
Flood-control pool	N/A
Recreation pool	9.7
Spillway crest	9.7

g. Dam.

Type	Rolled earth fill
Length	796 ft
Height	56 ft
Top width	18.6 ft
Side slopes	D/S, 2.1H to 1V; U/S, Unknown
Zoning	Unknown
Impervious core	Unknown (probably homogeneous section)
Cutoff	Unknown (probably to bedrock at shallow-depth)
Grout curtain	Unknown (probably none)

h. Diversion and regulating tunnel.

Type	None
Length	N/A
Closure	N/A
Access	N/A
Regulating facilities	None

i. Spillway.

Type	Trapezoidal concrete weir at right abutment.
Length of weir	54 ft (at elevation of dam crest)
Crest elevation	822.3 ft
Gates	None
Downstream channel	Concrete-lined upper reaches (Photo 3), soil and bedrock floored lower reaches, upper central reaches contain riprap for energy dissipations or erosion control (Photo 4).

j. Regulating outlets.

8 in. diameter iron pipe at toe of downstream face of dam (Photo 7). Could not be operated. No records of operations.

SECTION 2 ENGINEERING DATA

2.1 Design

No design plans or reports were found for Lonedell Lake Dam. The property owner at the time of construction, Mr Jack Patrick, is now deceased.

2.2 Construction

No records of construction methods or inspections were found for this dam. Mr Jack Rogers, a local resident, indicated the dam construction was begun in 1971 and completed in 1972. Following completion of the dam, it took approximately 3 years to fill the lake, according to Mr Rogers, due to the small drainage basin above the dam. Mr A. Wilson, a resident of the area, gave similar dates for the construction of the dam and filling of the lake.

2.3 Operation

No records were found documenting the operation of the valve and drain at the toe of the dam (it was not reliably determined that this pipe and valve are in fact low level outlets for the lake).

There are no records of overflow at the spillway or of water levels at this dam.

2.4 Evaluation

- a. Availability. The only engineering data obtained for this report was developed during the field inspection. No engineering design or construction reports were found for this dam.
- b. Adequacy. The available information is insufficient to evaluate the design of Lonedell Lake Dam. Seepage and stability analyses comparable to the requirements of the guidelines are not on record. This is a deficiency which

should be rectified. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record. These analyses should be performed by an engineer experienced in the design and construction of dams.

- c. Validity. Not applicable.

2.5 Project Geology

The dam site is located on the northern flank of the Ozark Structural dome. The regional dip is to the north. Bedrock in the area is mapped on the Geologic Map of Missouri as Ordovician-age Gasconade Formation, (Fig 4). It is a light-grayish brown cherty dolomite with a frequently-occurring basal sandstone. In the spillway discharge channel, bedrock exposures are quite sandy with thin blue-gray shale partings, indicating the dam is founded on the basal Gunter member of the Gasconade Formation.

In the central Ozarks, caves and springs are common in the Gasconade Formation. However, limited exposures in the site area preclude an evaluation of solution activity. Our visual inspection did not disclose any evidence of solution activity (e.g. water seepage, sinkholes, etc.) in the close vicinity of the dam.

The soils in the vicinity consist of a silty to fine sandy and gravelly clay (CL-CH). This soil appears to be a residual soil developed by weathering of the sandy Gasconade Formation. The gravel is chert and quartz typical of siliceous dolomite formations. The soils is mapped on the General Soils Map for Missouri (1979) as Union-Goss-Gasconade Peridge Association. The soil profiles exposed appeared relatively thin in the vicinity of the dam, on the order of 3 to 6 ft thick.

The principal northwest-southwest trending branch of the Ditch Creek Fault System is mapped approximately 0.5 mi northeast of the dam (Fig. 4). The fault is mapped as approximately 11 mi long on the Structural Features Map of Missouri, north side down, and offsets the Cambrian-age Eminence and Potosi Formations and the Ordovician-age Gasconade and Roubidoux Formations at the surface. This fault, like most others in the Ozark area, is not considered to be in a seismically active area and is not considered to pose a hazard to the dam.

SECTION 3 VISUAL INSPECTION

3.1 Findings

- a. General. A field visit and visual inspection was made of Lonedell Lake dam on 2 June, 1980. On the basis of this inspection, the dam is judged to be in generally fair condition.
- b. Dam. The dam was constructed of a rocky clay fill consisting of 40 to 50 percent angular chert gravel in a dark red, very plastic residual clay (CH). The gravel appears well graded from sand-size to cobble-size.

Several small animal burrows (1 to 2 in. in diameter, depth unknown) were noted on the crest and on the downstream face of the embankment.

The slopes and crest of the dam are generally grass-covered with scattered small bushes. Small willow trees are growing near the discharge channel at the toe of the right abutment.

The vertical and horizontal alignment of the dam appear undisturbed. Several minor slumps and one moderate size landslide were noted on the south half of the face of the dam.

The smaller slumps, perhaps 10 ft across the toe, and involving several cubic yards of material, occur at the toe of the dam in the upper portion of the discharge channel.

The larger landslide, the limits of which are outlined by standing persons in photograph 5, is approximately 15 to 20 ft in height, and measures about 100 ft across the toe. The depth of the slide is unknown. The scarp shows about 2 to 4 ft of vertical offset at the top, and ¼ to ½ in. wide cracks were noted along the scarp.

Scarps for all the slumps and for the landslide are grass covered and indistinct. They do not appear to be recent developments.

These slides may be the result of oversteepening of the embankment from erosion at the toe of the slope, where the discharge channel locally encroaches on the embankment (see Photo 4 and Section 3.1.c.2).

Minor seepage and associated willows and cattails were noted along most of the toe of the south half of the dam. Total seepage for this area at the time of the inspections was estimated at approximately 5 gal/min.

There is no riprap on the upstream slope. Wave erosion has cut a notch in the upstream bank of the dam (Photo 1). This erosion has removed the protective vegetation and while the erosion is quite moderate at present, it will likely continue unless some form of slope protection is provided.

c. Appurtenant Structures.

1. Spillway. The spillway is a trapezoidal concrete weir, approximately 54 ft wide at the level of the dam crest and 29.2 ft wide across the crest of the spillway. The south or abutment end of the spillway is unlined; the north or dam end of the spillway is concrete or gunite lined. A concrete apron extends approximately 15 ft downstream from the spillway weir.

2. Outlet works. An 8 in. diameter cast iron pipe exits the toe of the dam at elevation 775.7 ft (Photo 7). Adjacent to the pipe is part of a 55 gallon drum embedded vertically in the embankment. During the field inspection we could not gain access into the drum, but noted what appeared to be a valve control wheel. A maintenance man (no name available) said he never had recollected a time when the valve was being operated. It is assumed to be inoperative.

- d. Reservoir area. The slopes surrounding the reservoir are for the most part wooded, with scattered residences and summer homes. The slopes are generally flatter than 5 horizontal to 1 vertical, although locally steeper slopes were noted. Evidence of unstable slopes was not noted during the field inspection.

Post-construction changes around the reservoir consist of limited clearing of trees for home construction and gravel road building for access to these homes.

Sedimentation in the reservoir appears limited to minor bar development near the mouth of streams entering the lake.

- e. Downstream channel. The downstream channel for Lonedell Lake Dam is approximately .1 mi long and flows into the impoundment of Lake Aggravation Dam (Missouri Inventory number 30557). The head of the downstream channel at the end of the concrete apron is eroded about 2 ft deep due to lack of erosion protection beyond the concrete apron. Farther downstream, large size rocks have been dumped for erosion control and/or energy dissipation. However, these rocks have diverted the flow of water and created a tendency for the downstream channel to move towards the toe of the dam and undermine the embankment. Where it appears that the channel has encroached on the embankment (Photo 4), oversteepening has resulted in slumping of the embankment.

3.2 Evaluation

The visual inspection identified several deficiencies at this dam and its appurtenant structures which lead us to classify the dam as being in fair condition.

Specifically, the moderate size landslide on the right half of the embankment requires a more thorough investigation to evaluate its impact on the stability of the dam. The encroachment of the downstream channel on the toe of the dam could lead to additional erosion and slope failures which would adversely affect the stability of the dam.

SECTION 4 OPERATIONAL PROCEDURES

4.1 Procedures

So far as could be determined there are no written operational procedures for this dam. The water level in the reservoir is controlled by the crest of the ungated concrete weir.

4.2 Maintenance of Dam

No records of maintenance on this facility were available.

4.3 Maintenance of Operating Facilities

The cast iron pipe and valve control, assumed to be a low level outlet from the lake appeared to be inoperative at the time of the inspection. No records were available on maintenance or operation of this outlet.

4.4 Description of Any Warning System in Effect

The inspection did not identify any warning system in effect at this facility.

4.5 Evaluation

There is apparently no maintenance program in effect at this facility. In view of the erosion and associated slumping observed along the discharge channel, and the potentially adverse effect this could have on the stability of the dam, it is recommended a maintenance program be established for this dam and appurtenant facilities. The feasibility of a practical warning system should be evaluated to advise downstream residents, should potentially hazardous conditions develop during periods of heavy precipitation.

SECTION 5 HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

- a. Design data. No hydrologic or hydraulic information was available for evaluation of the dam. Pertinent dimensions of the dam and reservoir were surveyed on 30 May, 1980, measured during the field inspection or estimated from topographic mapping. The map used in the analysis is the advance copy of the USGS Richwoods NE 7.5 minute quadrangle map.
- b. Experience data. No recorded rainfall, runoff, discharge or pool stage data were available for this reservoir or watershed.
- c. Visual observation. On the date of the inspection, no conditions were noted which could lead to a reduced spillway capacity during a flood occurrence. Other observations regarding the reservoir, spillway and downstream channel are presented in Section 3, Visual Inspection.
- d. Overtopping potential. For the purpose of determining the overtopping potential of Lonedell Lake Dam, a discharge rating of $1403 \text{ ft}^3/\text{sec}$ was calculated for the spillway, with reservoir water level at the top of the dam. Hydrologic analysis of the dam and spillway using the data and method as enclosed and described in Appendix B, Hydraulic/Hydrologic Data and Analyses, indicate the reservoir storage and spillway will pass floods up to 85 percent of the Probable Maximum Flood (PMF) without overtopping the dam. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

A flood with 1 percent probability-of-occurrence (100-year flood) will be contained within the spillway without overtopping the dam.

The following data were computed for various flood events:

Precipitation Event	Maximum Depth of Overtopping ft	Maximum Lake Elevation ft (MSL)	Maximum Outflow, ft ³ /s	Duration of Overtopping, hrs
25% PMF	0	824.40	371	0
50% PMF	0	825.75	782	0
85% PMF	0	827.33	1374	0
100% PMF	0.50	827.90	1684	0.67

SECTION 6 STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

- a. Visual inspection. The visual inspection of Lonedell Lake Dam revealed no evidence of horizontal or vertical displacement of the dam crest alignment.

Several small to moderate size slumps and one landslide were noted along the toe of the south half of the dam (Fig. A-1, Appendix A). Seepage at the toe of these slides was estimated at approximately 5 gal/min.

Encroachment of the discharge channel on the toe of the south half of the dam and subsequent erosion in this area is expected to continue to reduce the stability of this portion of the dam.

- b. Design and construction data. No design or construction data were available for this dam. In particular, 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 operating records or water level records are maintained for this facility.
- d. Post construction changes. The lack of design or construction reports precludes the identification of changes in the dam or surrounding area. Changes are likely limited to lot clearing for construction of new homes and gravel road building to provide access to the new homes.
- e. Seismic stability. The dam is Seismic Zone 2, to which the guidelines assign a moderate damage potential. In view of the gravelly clay used in the construction of the dam, liquefaction of the embankment is unlikely during a seismic event. However, since no static stability analysis is available for review, the seismic stability cannot be evaluated.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

- a. **Safety.** Based on the visual inspection, Lonedell Lake Dam is classified as being in generally fair condition.

This judgment is based on the small to moderate size slumps and landslide identified along the south half of the dam, and on the potential for continued erosion of the toe and encroachment of the discharge channel in the toe of the dam.

The reservoir storage and spillway capacity will pass 85 percent of the PMF without overtopping the dam. The spillway discharge capacity is calculated at 1403 ft³/sec.

- b. **Adequacy of information.** The visual inspection provided a reasonable base of information for the conclusions and recommendations presented in this Phase I report.

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 analyses should be conducted under the direction of an engineer experienced in the construction of earth dams.

- c. **Urgency.** The deficiencies described in this report could affect the safety of the dam. Corrective actions should be initiated promptly.
- d. **Necessity for Phase II.** In accordance with the "Recommended Guidelines for Safety Inspections of Dams", the subject investigation was a minimum study. This study revealed that additional in-depth investigations are needed to complete the assessment of the safety of the dam. Those investigations which should be performed without undue delay are described in Section 7.2.b. It is

our understanding from discussions with the St Louis District that any additional investigations are the responsibility of the owner.

7.2 Remedial Measures

a. Alternatives. There are several general options which may be considered to reduce the possibility of dam failure. Some of these options are:

1. Remove the dam, or breach it to prevent storage of water.
2. Increase the height of the dam and/or the size of the spillway to pass the Probable Maximum Flood without overtopping the dam.
3. Purchase downstream land that would be adversely impacted by dam failure and restrict human occupancy.
4. Enhance the stability of the dam to permit overtopping by the Probable Maximum Flood without failure.
5. Provide a highly reliable flood warning system (generally does not prevent damage but decreases chances of loss of life).

b. Recommendations. Based on our inspection of Lonedell Lake Dam, it is recommended that further study be conducted without undue delay under the guidance of an engineer experienced in design and construction of dams to evaluate, as a minimum, the following topics:

1. Potential for erosion during periods of heavy flow within the spillway and adjacent portion of the embankment, including erosion mitigating options.
2. Potential for erosion and lateral migration in the discharge channel, including erosion mitigating options.

c. Operation and maintenance procedures. In view of the observed slumps and landslide, and the erodibility of the spillway and discharge channel, the potential for deterioration of the stability of the dam indicates a program of periodic inspections should be designed and implemented for this facility. Any deterioration of the dam conditions should be called to the attention of an engineer experienced in design and construction of dams. This program should include:

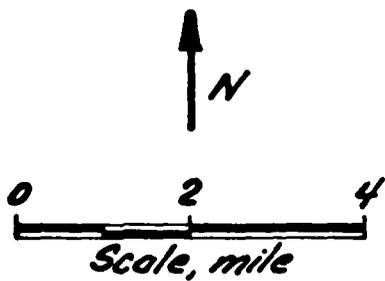
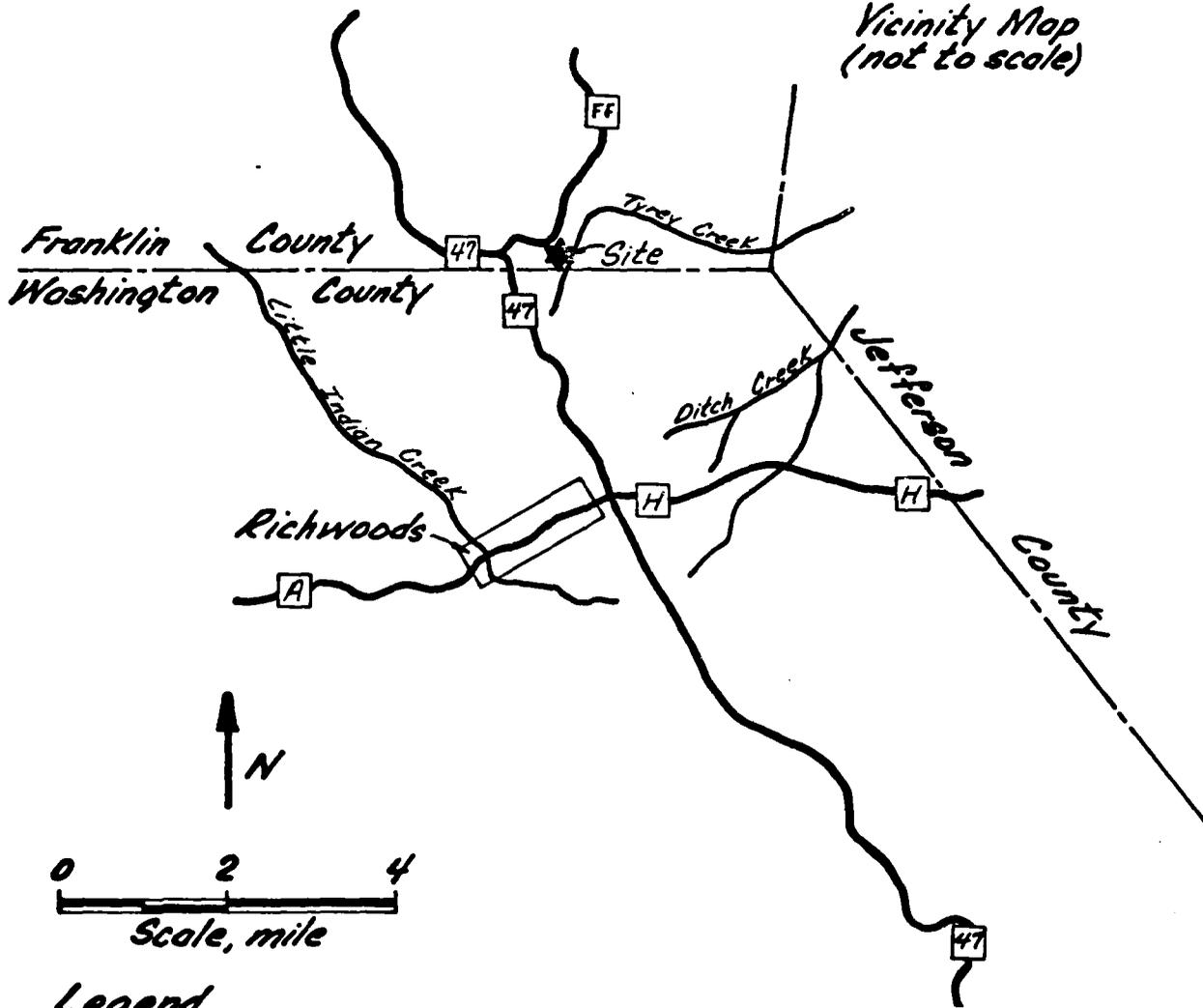
1. A monitoring program to periodically check the condition of the face of the dam to identify further slumping or landslides.
2. Monitoring of seepage to identify changes in the amount of seepage flow or turbidity (soil) of the seepage water.
3. Inspection of the spillway and discharge channel for evidence of substantial erosion which could pose a hazard to the embankment stability.

REFERENCES

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- US Department of Commerce, US Weather Bureau, 1956, "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24 and 48 Hours," Hydrometeorological Report No. 33.
- US Soil Conservation Service, 1971, "National Engineering Handbook," Section 4, Hydrology, 1971.



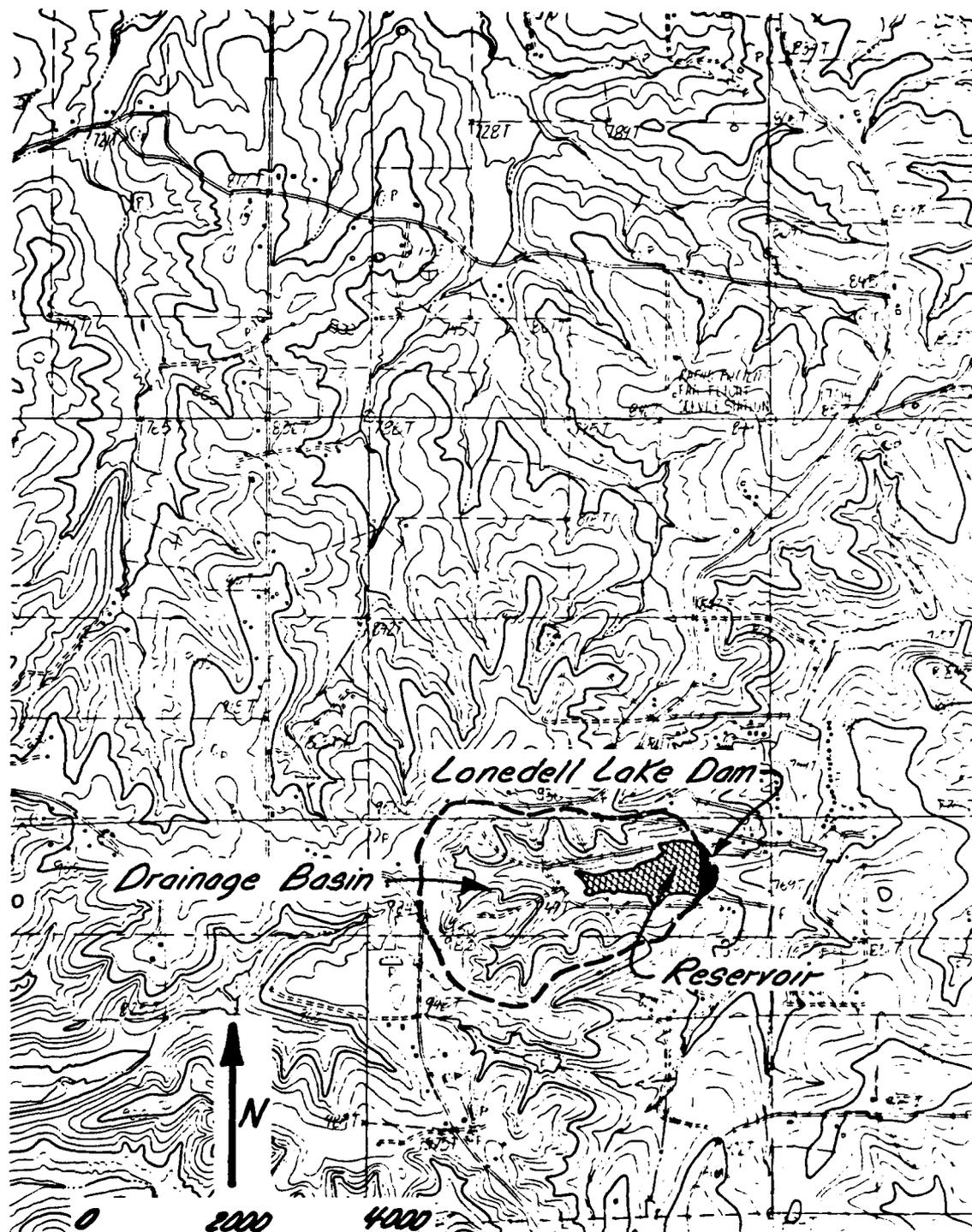
Vicinity Map
(not to scale)



Legend

- County line
- State highway and Route No.
- River or creek
- City or town
- Project location

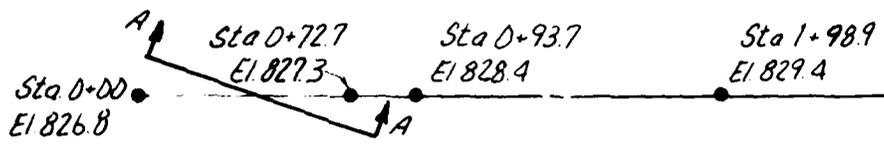
SITE LOCATION MAP	
LONEDELL LAKE DAM	
MO. 31395	Fig. /



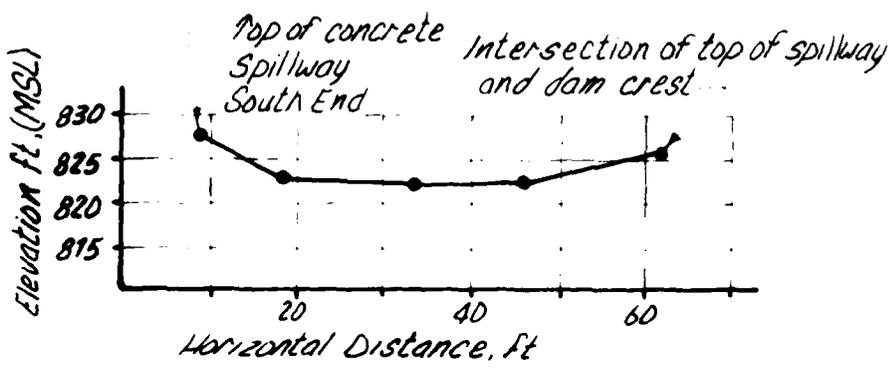
1. Topography obtained from
 U.S.G.S. Richwoods N.E.
 7 1/2 minute quadrangle
 map.

DRAINAGE BASIN AND SITE TOPOGRAPHY	
LONEDELL LAKE DAM	
MO. 31395	Fig. 2

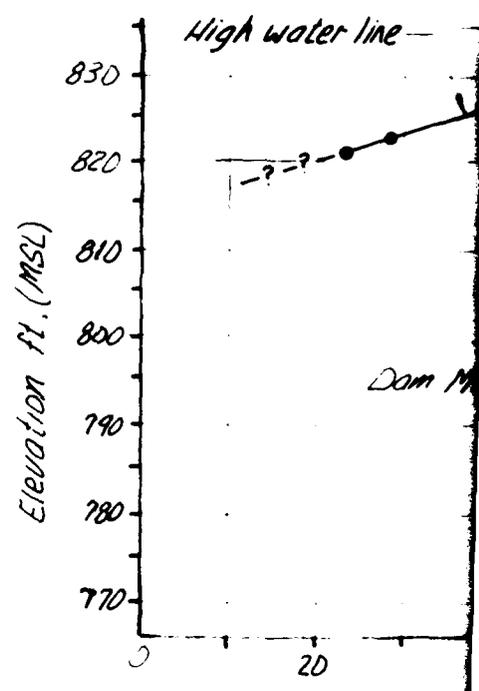
LAKE



PLAN OF DAM CREST



SECTION A-A
Spillway Cross-Section

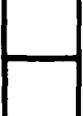
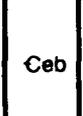
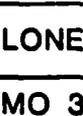


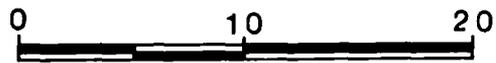
Notes:
 Surveyed by James F. McCaul, III and Associa
 Potosi, Missouri
 Date of survey: 30 Ma

Dam Location



Legend

-  Roubidoux Formation
-  Gasconade Dolomite
Gunter Sandstone Member
-  Eminence Dolomite
-  Potosi Dolomite
-  Derby-Doerun Dolomite
-  Davis Formation
-  Bonneterre Formation
Whetstone Creek Member
Sullivan Siltstone Member
-  Reagan Sandstone
(subsurface, western Missouri)
-  Lamotte Sandstone
-  Diabase (dikes and sills)
-  St. Francois Mountains Intrusive Suite
-  St. Francois Mountains Volcanic Supergroup

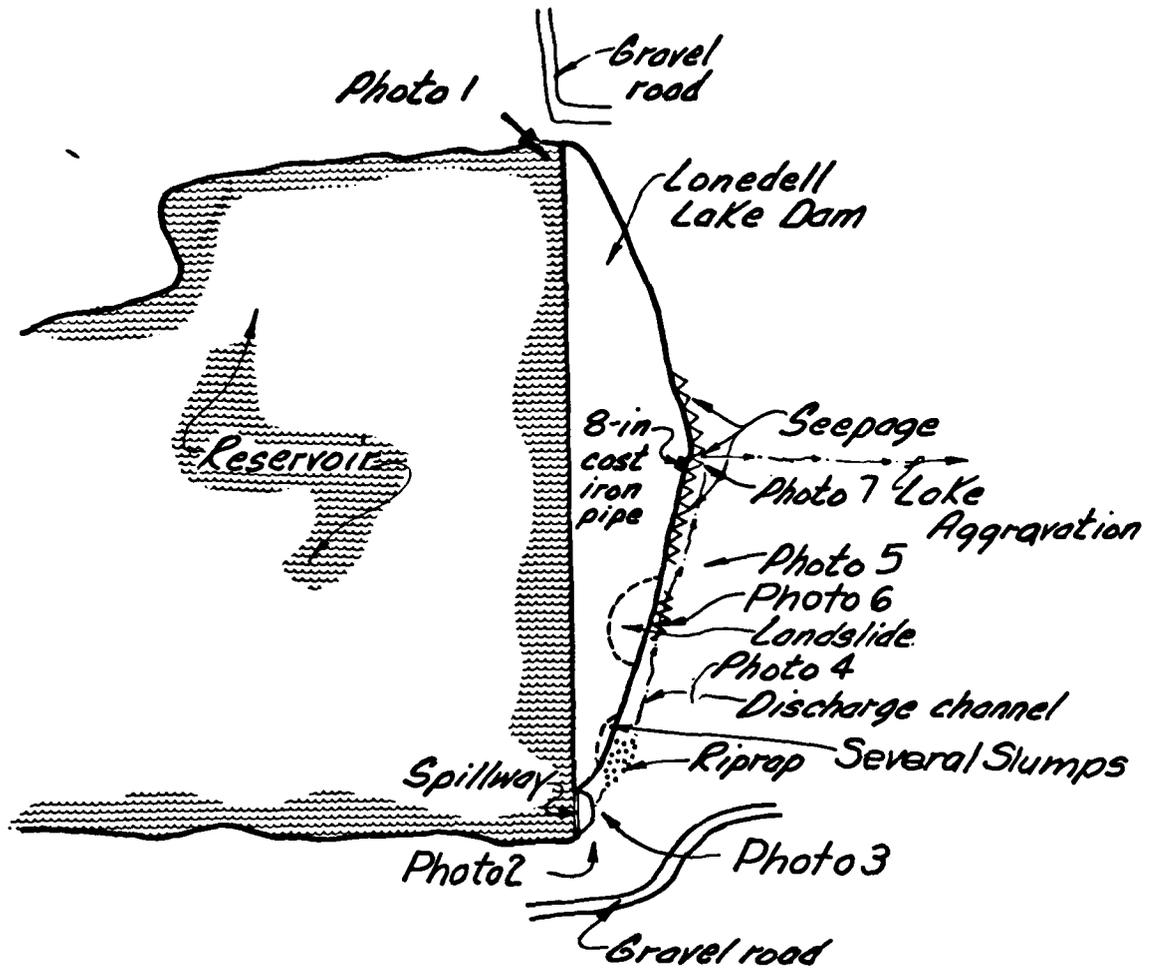


Scale, mile

REGIONAL GEOLOGIC MAP	
LONEDELL LAKE DAM	
MO 31395	Fig. 4

APPENDIX A

Photographs



Legend:
 Downstream Channel

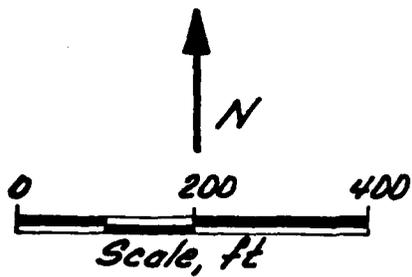


PHOTO LOCATION SKETCH	
LONEDELL LAKE DAM	
MO. 31395	Fig. A-1



1. Wave cut erosion, upstream edge of Lonedell Lake Dam looking south.



2. Spillway weir and concrete apron looking north.



3. Erosion at downstream edge of spillway concrete apron looking northwest.



4. Erosion at toe of dam where riprap diverts discharge channel looking south.



5. Personnel outlining scarp of 100 ft wide landslide on face of dam looking southwest. Note willow tree and water weeds from seepage at toe of slide.



6. Seepage from base of tree, at toe of landslide in Photo 5.



7. Discharge pipe at toe of Lonedell Dam.

APPENDIX B

Hydraulic/Hydrologic Data and Analyses

APPENDIX B

Hydraulic/Hydrologic Data and Analyses

B.1 Procedures

- a. **General.** The hydraulic/hydrologic analyses were performed using the "HEC-I, Dam Safety Version (1 Apr 80)" computer program. Inflow hydrographs were developed by applying various precipitation events to a synthetic unit hydrographs. The inflow hydrographs, thus obtained, were then routed through the reservoir and appurtenant structures by the modified Puls reservoir routing method used in the HEC-I program to determine overtopping potential.
- b. **Precipitation events.** Various percentages including 100 percent of the Probable Maximum Precipitation (PMP) and the 1 and 10 percent probability-of-occurrence events were used in the analyses. The PMP was determined from regional charts prepared by the US Weather Bureau (1956). The 1 and 10 percent probability-of-occurrence events were provided by SLD.
- c. **Unit hydrograph.** The Soil Conservation Service (SCS) unit hydrograph (SCS, 1971) for a storm duration of 48 hrs was used to develop the inflow hydrograph. The unit hydrograph was divided into 10 min increments.
- d. **Infiltration losses.** The SCS curve number (CN) method was used to compute infiltration losses. Curve numbers were selected on the basis of antecedent moisture conditions in accordance with the guidelines, present land usage and hydrologic soil group of the soils in the drainage basin. Where more than one soil group was present, the group giving the highest CN was used for the entire basin.
- e. **Lag time.** Lag time was computed by the SCS method (National Engineering Handbook 4, Equation 15-4).

B.2 Pertinent Data

- a. **Drainage area:** 0.28 mi²
- b. **Lag time:** 0.50 hr
- c. **Hydrologic soil group:** B
- d. **SCS curve numbers:**
 1. For PMF: 74 (AMC III)
 2. For 1 and 10 percent probability-of-occurrence events: 55 (AMCII)

- e. **Storage.** Elevation-area data were developed by planimetering areas at various elevation contours on the USGS Richwoods NE 7.5-minute quadrangle map. The data were entered on the \$A and \$E cards so that the HEC-I program could compute storage volumes.
- f. **Outflow capacity.** The spillway rating curve was computed by the intrinsic formula within the HEC-I program. Pertinent spillway data required by the program were entered on the \$\$ card.
- g. **Outflow over crest.** As the profile of the dam crest is irregular, flow over the crest cannot be determined by conventional weir formulas. Crest length-elevation data and hydraulic constants for the crest were entered on \$D, \$L and \$V cards.
- h. **Reservoir elevations.** For all fractions of the PMF, the starting reservoir elevation was the spillway crest elevation of 822.3 ft. For the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was also 822.3 ft.

B.3 Results

Results of the analyses, as well as the input values to the HEC-I program pertaining to various fractions of the Probable Maximum Flood (PMF), follow in this Appendix. Only results summaries are included, not intermediate output. Complete copies of the HEC-I input and output are available in the project file.

END-OF-PERIOD-FLOW

COMP

LOSS

EXCS

RAIN

PERIOD

HR.MN

MO.DA

COMP O

LOSS

EXCS

RAIN

PERIOD

HR.MN

MO.DA

COMP

Input Data
Various PMF Events
Lonedell Lake Dam
MO 31395

1.01	20.10	121	.00	.00	.00	.00	.00	2.0	1.02	20.10	265	.04	.04	.00	.00	48.
1.01	20.20	122	.00	.00	.00	.00	.00	2.0	1.02	20.20	266	.04	.04	.00	.00	48.
1.01	20.30	123	.00	.00	.00	.00	.00	2.0	1.02	20.30	267	.04	.04	.00	.00	47.
1.01	20.40	124	.00	.00	.00	.00	.00	2.0	1.02	20.40	268	.04	.04	.00	.00	47.
1.01	20.50	125	.00	.00	.00	.00	.00	2.0	1.02	20.50	269	.04	.04	.00	.00	47.
1.01	21.00	126	.00	.00	.00	.00	.00	2.0	1.02	21.00	270	.04	.04	.00	.00	47.
1.01	21.10	127	.00	.00	.00	.00	.00	2.0	1.02	21.10	271	.04	.04	.00	.00	47.
1.01	21.20	128	.00	.00	.00	.00	.00	2.0	1.02	21.20	272	.04	.04	.00	.00	47.
1.01	21.30	129	.00	.00	.00	.00	.00	2.0	1.02	21.30	273	.04	.04	.00	.00	47.
1.01	21.40	130	.00	.00	.00	.00	.00	2.0	1.02	21.40	274	.04	.04	.00	.00	47.
1.01	21.50	131	.00	.00	.00	.00	.00	2.0	1.02	21.50	275	.04	.04	.00	.00	47.
1.01	22.00	132	.00	.00	.00	.00	.00	2.0	1.02	22.00	276	.04	.04	.00	.00	47.
1.01	22.10	133	.00	.00	.00	.00	.00	2.0	1.02	22.10	277	.04	.04	.00	.00	47.
1.01	22.20	134	.00	.00	.00	.00	.00	2.0	1.02	22.20	278	.04	.04	.00	.00	47.
1.01	22.30	135	.00	.00	.00	.00	.00	2.0	1.02	22.30	279	.04	.04	.00	.00	47.
1.01	22.40	136	.00	.00	.00	.00	.00	2.0	1.02	22.40	280	.04	.04	.00	.00	47.
1.01	22.50	137	.00	.00	.00	.00	.00	2.0	1.02	22.50	281	.04	.04	.00	.00	47.
1.01	23.00	138	.00	.00	.00	.00	.00	2.0	1.02	23.00	282	.04	.04	.00	.00	47.
1.01	23.10	139	.00	.00	.00	.00	.00	2.0	1.02	23.10	283	.04	.04	.00	.00	47.
1.01	23.20	140	.00	.00	.00	.00	.00	2.0	1.02	23.20	284	.04	.04	.00	.00	47.
1.01	23.30	141	.00	.00	.00	.00	.00	2.0	1.02	23.30	285	.04	.04	.00	.00	47.
1.01	23.40	142	.00	.00	.00	.00	.00	2.0	1.02	23.40	286	.04	.04	.00	.00	47.
1.01	23.50	143	.00	.00	.00	.00	.00	2.0	1.02	23.50	287	.04	.04	.00	.00	47.
1.02	0.	144	.00	.00	.00	.00	.00	2.0	1.03	0.	288	.04	.04	.00	.00	47.
SUM											36.40	32.89	3.51	35598.		
											(925.11	835.11	89.11	1000.72)	

Input Data
Various PMF Events
Lonedell Lake Dam
MO 31395

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (GAUGE METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN RATIO 1	RATIO 2	RATIO 3	RATIO 4

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	ELEVATION STORAGE OUTFLOW	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
		827.30	822.37	827.40
		136.	136.	191.
		0.	0.	1403.

RATIO OF PMF	MAXIMUM RESERVOIR STORAGE W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.85	827.33	0.	191.	1374.	0.	40.33	0.
.90	827.54	.14	193.	1460.	.33	40.33	0.
.95	827.71	.33	195.	1565.	.50	40.33	0.
1.00	827.90	.70	198.	1684.	.67	40.33	0.

Output Summary
 Various PMF Events
 Lonedell Lake Dam
 MO 31395

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN-CUBIC-Feet-Per-Second (GIGALITERS-Per-Second)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN RATIO	RATIOS APPLIED TO FLOWS			
				RATIO 1	RATIO 2	RATIO 3	RATIO 4
HYDROGRAPH AT	0-141	.20	1	.490	.076	1466	1952
		.731	1	13.0231	27.6311	41.4511	55.2611
WUVEE TO	0441	.20	1	.324	.022	1204	1684
		.731	1	10.5111	22.1411	34.1011	47.6811

SUMMARY OF DAM SAFETY ANALYSIS

PLAN	ELEVATION	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM	RATIO	MAXIMUM RESERVOIR DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW 40UPS	TIME OF FAILURE HOURS
	827.90	0.0	822.50	927.40	.25	0.0	197	376	0.0	40.50	0.0
	136	0.0	136	191	.50	0.0	172	782	0.0	40.33	0.0
	0.0	0.0	0.0	1403	.75	0.0	145	1204	0.0	40.33	0.0
					1.00	0.0	196	1694	0.0	40.33	0.0

Output Summary
 Various PMF Events
 Lonedell Lake Dam
 MO 31395

**END
DATE
ILME**