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BLACK AND VEATCH KANSAS CITY MO
NATIONAL DAM SAFETY PROGRAM. ODD FELLOWS HOME LAKE DAM (MO 1102--ETC(U)
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OLD FELLOWS HOME LAKE DAM

CLAY COUNTY, MISSOURI

NO 11822

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PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM



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

St. Louis District

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

FOR STATE OF MISSOURI

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Odd Fellows Home Lake (MO 11022) Clay County, Missouri		5. TYPE OF REPORT & PERIOD COVERED Final Report
6. AUTHOR(s) Black & Veatch, Consulting Engineers		7. PERFORMING ORG. REPORT NUMBER
8. 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		9. CONTRACT OR GRANT NUMBER(s) DAON 3-84-C-1174
10. 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		11. PROGRAM ELEMENT, SUBJECT, TASK AREA & WORK UNIT NUMBERS 12)
12. DISTRIBUTION STATEMENT (of this Report) Approved for release; distribution unlimited.		13. REPORT DATE May 1984
14. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		14. NUMBER OF PAGES Approximately 50
15. SUPPLEMENTARY NOTES		15. SECURITY CLASS. (of this report) UNCLASSIFIED
16. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams		16. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		

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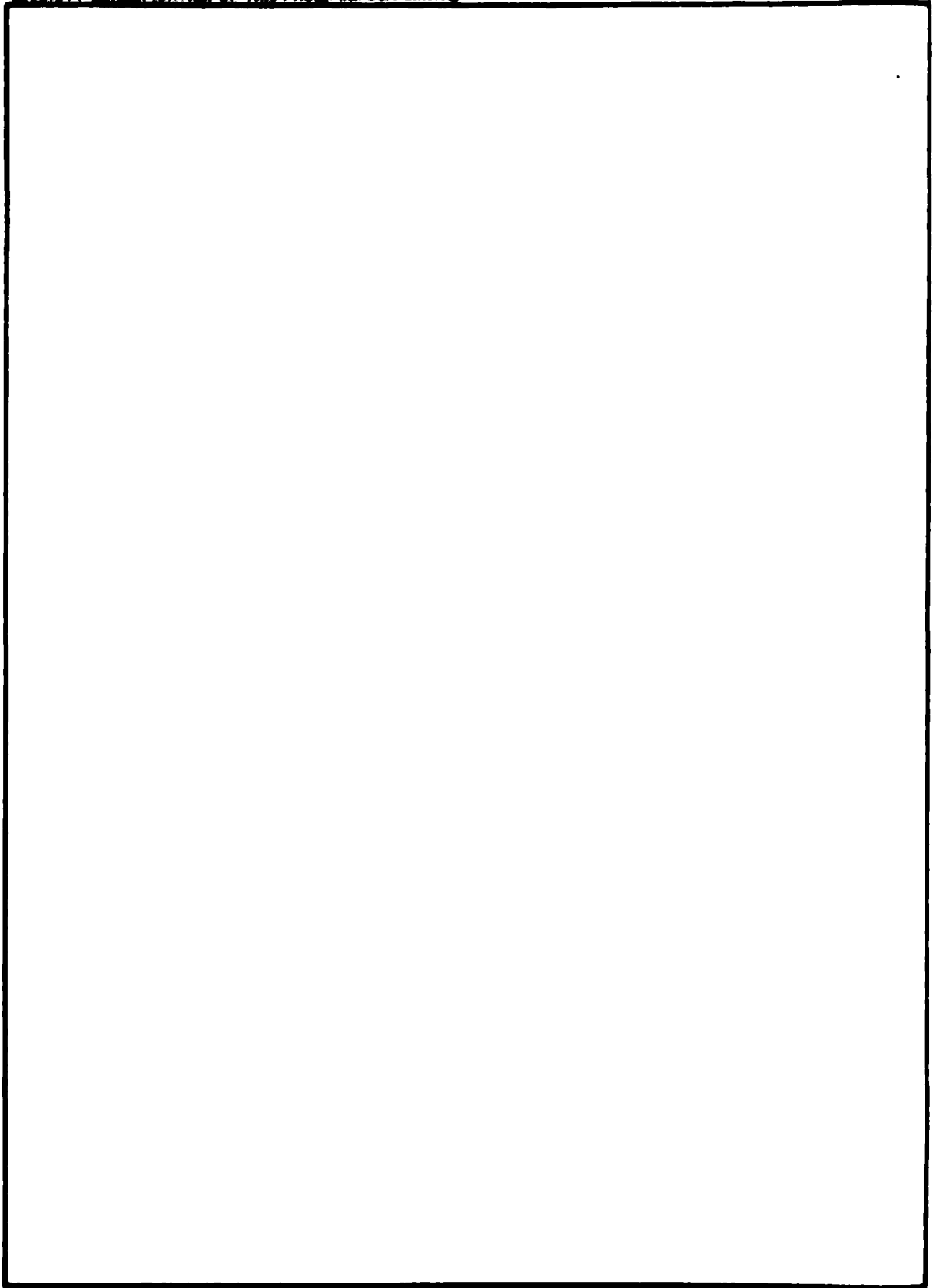
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CLAY COUNTY, MISSOURI
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PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM



United States Army
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St. Louis District

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

FOR: STATE OF MISSOURI

MAY 1990



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

REPLY TO
ATTENTION OF

LMSD-PD

SUBJECT: Odd Fellows Home Lake Dam, MO. I.D. No. 11022
Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Odd Fellows Home Lake Dam.

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

This dam has been classified as unsafe, non-emergency due to a seriously inadequate spillway 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: _____
Chief, Engineering Division Date

APPROVED BY: _____
Colonel, CE, District Engineer Date

ODD FELLOWS HOME LAKE DAM

CLAY COUNTY, MISSOURI

MISSOURI INVENTORY NO. 11022

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 1980

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Odd Fellows Home Lake Dam
State Located	Missouri
County Located	Clay County
Stream	Town Branch of Shoal Creek
Date of Inspection	8 May 1980

Odd Fellows Home 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.

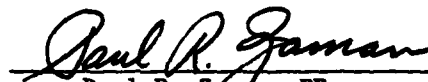
The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as a small 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 a waterworks with appurtenant structures, seven dwellings, a building, and twelve trailers homes. Contents of the downstream damage zone were verified by the inspection team.

Our inspection and evaluation indicates the spillways do not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillways will pass neither 50 nor 100 percent of the probable maximum flood without overtopping but will pass 10 percent of the probable maximum flood. The spillway will not 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 50 to 100 percent of the probable maximum flood. Considering the small volume of water impounded behind the dam, the presence of an embankment in the valley below the dam, and the hazard zone, the spillway design flood should be 50 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.

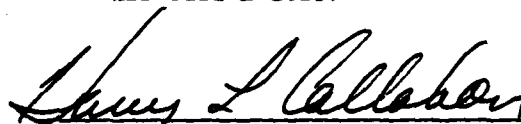
Based on visual observations, this dam appears to be in satisfactory condition. Deficiencies visually observed by the inspection team were extremely dense grass, tree, and brush cover, irregular surfaces of

the crest and side slopes, seepage at the toe of the right abutment, erosion at the left abutment, the presence of a leaking sewer line near the left abutment, and the absence of adequate slope protection on the upstream face. 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.


Paul R. Zaman, PE
Illinois 62-29261


Edwin R. Burton, PE
Missouri E-10137


Harry L. Callahan, Partner
Black & Veatch



OVERVIEW OF DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
ODD FELLOWS HOME LAKE DAM

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Appendix A - Hydrologic and Hydraulic Analyses

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 Odd Fellows Home 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 the Town Branch of Shoal Creek (see Plate 1). The watershed area is hilly consisting of farmland and Odd Fellows Home facilities (see Plate 2). The dam is approximately 440 feet long along the crest and 23 feet high. The dam crest is 9 feet wide. The downstream face of the dam has a fairly uniform slope from the crest to the valley floor below.

(2) The primary spillway from the lake is an uncontrolled 24-inch steel pipe with antivortex plate installed in the embankment. Flow through the pipe discharges into a basin confined by the subject embankment and what is believed by the inspection team to be a haul road embankment with a 24-inch reinforced concrete pipe through the embankment which discharges to the natural stream channel below. The emergency spillway consists of a triangular cut in the natural overburden and embankment. Discharge through the emergency spillway overflows to the same basin as does the primary spillway.

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

b. Location. The dam is located in south-central Clay 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 Liberty, Missouri in Section 17 of T51N, R31W.

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 Odd Fellows Home 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 the Odd Fellows Home Lake Dam the estimated flood damage zone extends approximately two miles downstream of the dam. Within the estimated damage zone are a waterworks with appurtenant structures, seven dwellings, a building, and twelve trailer homes. Contents of the downstream damage zone were verified by the inspection team.

e. Ownership. The dam is owned by the Odd Fellows Home Association, Inc., Route 6 Box 194, Liberty, Missouri 64068, Telephone 816-781-4880.

f. Purpose of Dam. The dam forms a 6-acre lake used for recreation.

g. Design and Construction History. According to Helen White, Administrator, the dam is nearly 100 years old. No specific date, design, nor construction data were available.

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

1.3 PERTINENT DATA

a. Drainage Area - 487 acres

b. Discharge at Damsite.

(1) Normal discharge at the damsite is through an uncontrolled 24-inch outlet pipe which discharges to an area between the dam and a haul road embankment through which a 24-inch reinforced concrete pipe discharges to the natural stream channel below.

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

(3) Estimated ungated spillway capacity at maximum pool elevation 730 cfs (50 Percent Probable Maximum Flood Pool El.781.5).

c. Elevation (Feet above m.s.l.).

- (1) Top of dam - 779.5 (see Plate 3)
- (2) Emergency spillway crest - 777.8
- (3) Primary spillway pipe invert - 775.0
- (4) Streambed at toe of dam - 756.7
- (5) Maximum tailwater - Unknown.

d. Reservoir.

- (1) Length of maximum pool - 1,300 feet $\pm$ (50 Percent probable maximum flood pool level)
- (2) Length of normal pool - 1,000 feet $\pm$ (Primary spillway pipe invert)

e. Storage (Acre-feet).

- (1) Top of dam - 64
- (2) Emergency spillway crest - 50
- (3) Primary spillway pipe invert - 32
- (4) Design surcharge - Not available.

f. Reservoir Surface (Acres).

- (1) Top of dam - 9
- (2) Emergency spillway crest - 6.8
- (3) Primary spillway pipe invert - 6.3

g. Dam.

- (1) Type - Earth embankment
- (2) Length - 440 feet
- (3) Height - 23 feet $\pm$
- (4) Top width - 9 feet

(5) Side slopes - upstream face 1.0 V on 2.6 H, downstream face between 1.0 V on 2.0 H and 1.0 V on 2.4 H (see Plate 4)

(6) Zoning - Unknown.

(7) Impervious core - Unknown.

(8) Cutoff - Unknown.

(9) Grout curtain - Unknown.

h. Diversion and Regulating Tunnel - None.

i. Primary Spillway.

(1) Type - 24-inch steel pipe with antivortex plate.

(2) Inlet invert elevation - 775.0 feet m.s.l.

(3) Outlet invert elevation 758.7 feet m.s.l.

(4) Gates - None.

(5) Upstream channel - Not applicable.

(6) Downstream channel - An earth embankment is present immediately downstream of the primary spillway outlet which has a 24-inch concrete pipe to discharge to the natural open channel below.

j. Emergency Spillway.

(1) Type - Grass open channel.

(2) Width of channel - 86 feet.

(3) Emergency spillway crest - 777.8

(4) Gates - None.

(5) Upstream channel - Not applicable.

(6) Downstream channel - A haul road embankment is constructed in the valley immediately downstream of the dam. A 24-inch reinforced concrete pipe runs beneath the haul road embankment which permits primary and emergency spillway discharges to discharge downstream of the haul road to the natural channel.

k. Regulating Outlets - None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Design data were not available.

2.2 CONSTRUCTION

Construction records were unavailable.

2.3 OPERATION

Records of operation or of past floods were not available.

2.4 GEOLOGY

The site of the dam and reservoir is located in a broad shallow valley in gently rolling terrain. The dam is located on Town Branch of Shoal Creek.

The soil of the dam and reservoir area consists of the Sibley soil series. The Sibley series consists of deep, well-drained soils formed in loess on convex ridges and side slopes. The general depth of bedrock is greater than five feet. The soil is classified for engineering purposes as a low plastic clay (CL).

The bedrock of the dam and reservoir area consists of the Wyandotte formation of the Kansas City Group. The Wyandotte formation is composed of five members. These are, from the base upwards, the Frisbie, Quindaro, Argentine, Island Creek, and Farley members. The Frisbie, Argentine, and Farley members are composed of limestone and are separated by the Quindaro calcareous shale and the Island Creek shale, respectively.

2.5 EVALUATION

- a. Availability. No engineering data were available.
- b. Adequacy. No engineering data were available. Thus, an assessment of the 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 validity of the 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 Odd Fellows Home Lake Dam was made on 8 May 1980. The inspection team included professional engineers with experience in dam design and construction, hydrology, hydraulic engineering, and geotechnical engineering. The inspection team consisted of Edwin Burton, team leader; Robert Pinker, geologist; Gary Van Riessen, geotechnical engineer; John Ruhl, hydrologist/hydraulic engineer; Mark Snyder, hydrologist/hydraulic engineer; and Russell Burnham, structural engineer. The dam is 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. The crest of the dam is narrow and irregular. The upstream and downstream slopes are steep and of irregular slope. The upstream face has no riprap slope protection. Extremely dense tree, grass, and brush cover is typical of the embankment. Seepage of approximately 1 gpm was observed at the toe of the embankment at the right abutment. Erosion of embankment material was observed at the left abutment. A 12-inch sewer line and manhole on the downstream face near the left abutment was observed leaking raw sewage. It is evident that the sewer line is beneath the lake and embankment, although the line could not be observed. Flow in the sewer line was approximately 1/2 pipe flow. Typical of the embankment was trampled grass and brush which indicates probable animal activity. No animal burrows could be observed due to the dense vegetation on the embankment. The embankment material consisted of silty clay (CL). The embankment has no visible stability problems. There was no evidence to indicate that the embankment has been overtopped.

c. Appurtenant Structures. The inspection team observed the following items pertaining to appurtenant structures. The primary spillway consists of a 24-inch beveled steel pipe with antivortex plate which runs through the embankment. Several feet of the pipe which were observable at each end appeared to be in good condition. An earth embankment is constructed immediately below the primary spillway outlet. A 24-inch concrete pipe permits discharge through the downstream embankment at an elevation close to the primary spillway outlet. The inspection team speculates that the embankment was constructed as a haul road for earth fill for the nearby highway. The emergency spillway consisted of a triangular cut in the natural overburden and dam at the right abutment. There are no existing toe drains or relief wells.

d. Geology. The soil on the slopes around the reservoir and below the dam is formed in loess. No outcrops of rocks are present in the vicinity of the dam and reservoir. The depth to rock is estimated to be greater than twenty feet.

Samples of the embankment material were taken near the downstream crest on the left side of the embankment with an Oakfield sampler. The first two feet consisted of soft, moist silty clay with some organic matter. The next two feet were the same material except that it was firm and dry. The samples were visually classified in accordance with ASTM D 2488-69. Based on these samples, it is anticipated that the embankment consists of silty clay of low plasticity.

The abutments and foundation of the embankment are anticipated to be interbedded limestone and shale of the Wyandotte formation overlain by the Sibley soil series. These interpretations are based on visual observations and published data.

e. Reservoir Area. No slides or excessive erosion due to wave action were observed along the shore of the reservoir. It appeared at the time of the inspection that the lake has considerable siltation which may be attributed to recent highway construction within the drainage basin.

f. Downstream Channel. Downstream of the spillway outlet pipe is a haul road embankment with a culvert beneath the embankment which discharges to the original streambed.

3.2 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 12-inch sewer within the embankment near the left abutment does not in itself constitute a deficiency. However, the leakage of raw sewage from the sewer and manhole near the left abutment contributes to erosion and saturation of embankment material. The potential for sloughing, erosion, or sliding of embankment material is enhanced by the presence of the relatively steep side slopes and the narrow, irregular crest. The growth of trees and brush and the uncut grass, 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. Brush on the dam prevents inspection of the embankment and kills the smaller grasses whose roots are more effective in protecting the surface soil of the slope from erosion. The brush and tall uncut grass provides habitat for burrowing animals which can damage the embankment. The area of seepage at the toe of the dam at the right abutment which was observed should be

monitored regularly for quality and quantity. Seepage can cause internal erosion creating cavities and underground channels, thereby weakening the embankment and/or abutments.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is primarily controlled by rainfall, runoff, evaporation, transpiration, and capacity of the uncontrolled primary spillway outlet pipe.

4.2 MAINTENANCE OF DAM

No maintenance was evident.

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

A maintenance program should be initiated which would include mowing the grass cover on the embankment in order to discourage animal burrowing. The brush and trees on the embankment should be removed. The area of seepage should be monitored periodically and, if flow increases significantly or if seepage flow becomes muddy, a qualified engineer should be consulted.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. No design data were available.

b. Experience Data. The drainage area and lake surface area are developed from USGS Liberty Quadrangle Map. The dam layout is from a survey made during the inspection.

c. Visual Observations.

(1) The primary spillway appears to be in good condition. The lake level at the time of the inspection was below the inlet level and there was no flow through the pipe. Only the inlet and outlet ends were observable. Flow through the primary spillway pipe discharges into a basin confined by the subject embankment and what is believed by the inspection team to be a haul road embankment with a 24-inch reinforced concrete pipe through the embankment which discharges to the natural stream channel below. There were no obstructions to flow in the channel downstream of the haul road embankment.

(2) The emergency spillway channel is in good condition with no evidence of erosion at the time of the inspection.

(3) Spillway discharges do not endanger the integrity of the dam.

d. Overtopping Potential. The spillways 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 spillways will pass 10 percent of the probable maximum flood without overtopping the dam. The spillways will not pass the one percent chance flood estimated to have a peak outflow of 545 cfs developed by 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 small size should pass 50 to 100 percent of the probable maximum flood. Considering the small volume of water impounded by the dam, the presence of an embankment in the valley below the dam, and the downstream hazard, the appropriate spillway design flood should be 50 percent of the probable maximum flood. The portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 770 cfs of the total discharge from the reservoir of 1,500 cfs. The estimated duration of overtopping is 6.3 hours with a maximum height of 1.2 feet. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 2,040 cfs of the total discharge from the reservoir of 3,000 cfs. The estimated duration of

overtopping is 8.8 hours with a maximum height of 2.0 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. A waterworks with appurtenant structures, seven dwellings, twelve trailer homes, and a building could be severely damaged and lives could be lost should failure of the dam occur. Contents of the estimated downstream damage zone were verified by the inspection team.

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.lb.

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. An embankment has been constructed in the valley immediately below the dam. The inspection team speculates that the embankment served as a haul road for highway fill. A 24-inch reinforced concrete culvert allows primary spillway discharges to flow beneath the haul road embankment.

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. 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 of the left abutment, seepage from the right abutment at the embankment toe, the dense growth of grass, brush, and trees on the embankment, and the leakage of raw sewage from the sewer line near the left abutment. 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 and visual conditions. 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. A program should be developed as soon as possible to monitor at regular intervals the deficiencies described in this report. The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. 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 1. 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.

7.2 REMEDIAL MEASURES

a. Alternatives. The emergency spillway size and/or height of the dam would need to be increased or the lake level would need to be lowered to increase available flood storage in order to pass the spillway design flood. The emergency spillway should be protected to prevent erosion.

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

(1) Riprap should be placed on the upstream face of the dam at the normal lake level to prevent erosion of the embankment material.

(2) The seepage area noted during the visual inspection should be closely monitored and documented as to quantity of flow. Any significant changes should be evaluated.

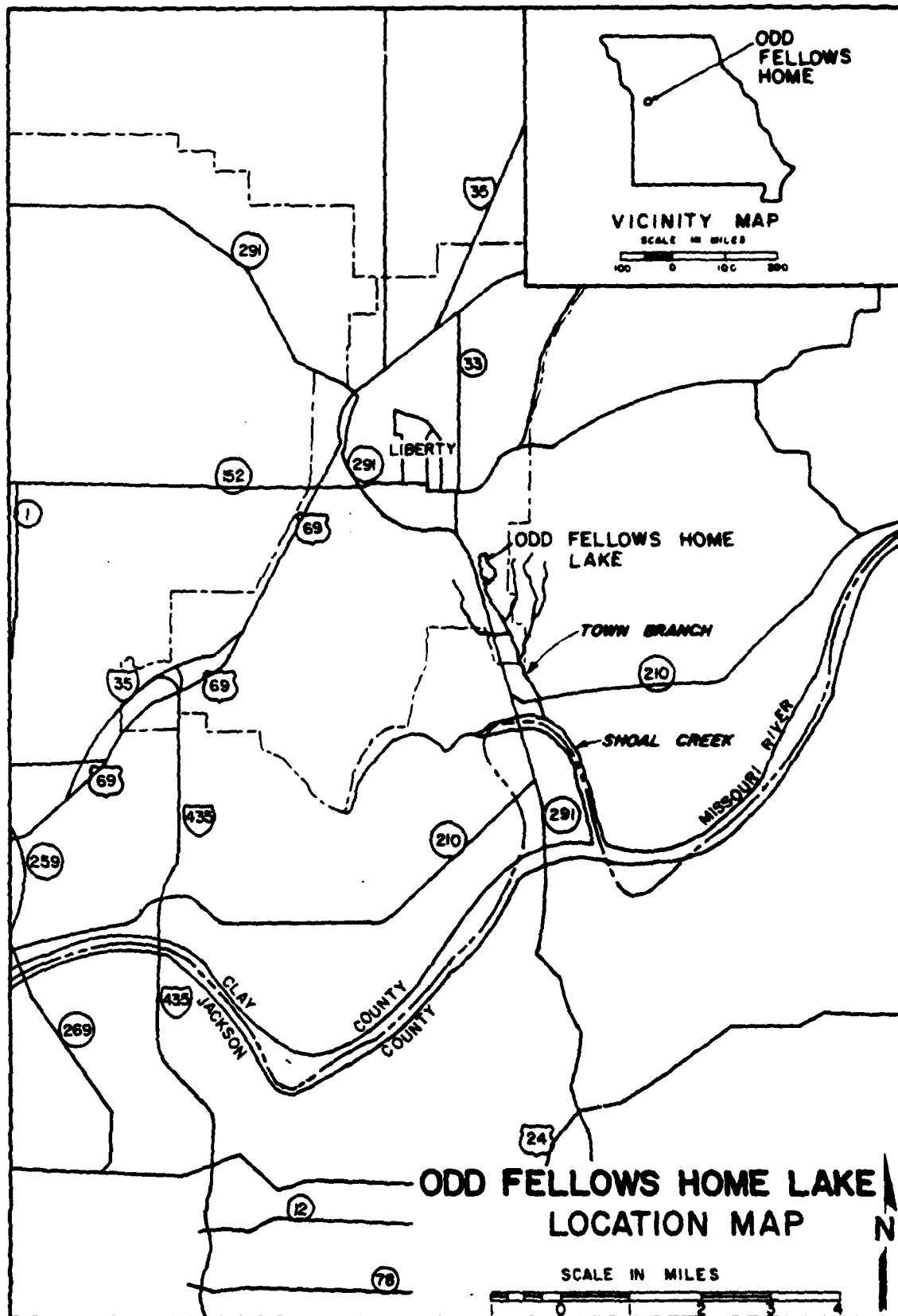
(3) An improved maintenance program to remove and control the growth of brush and trees on the embankment should be developed. Grass cover on the embankments should be cut periodically.

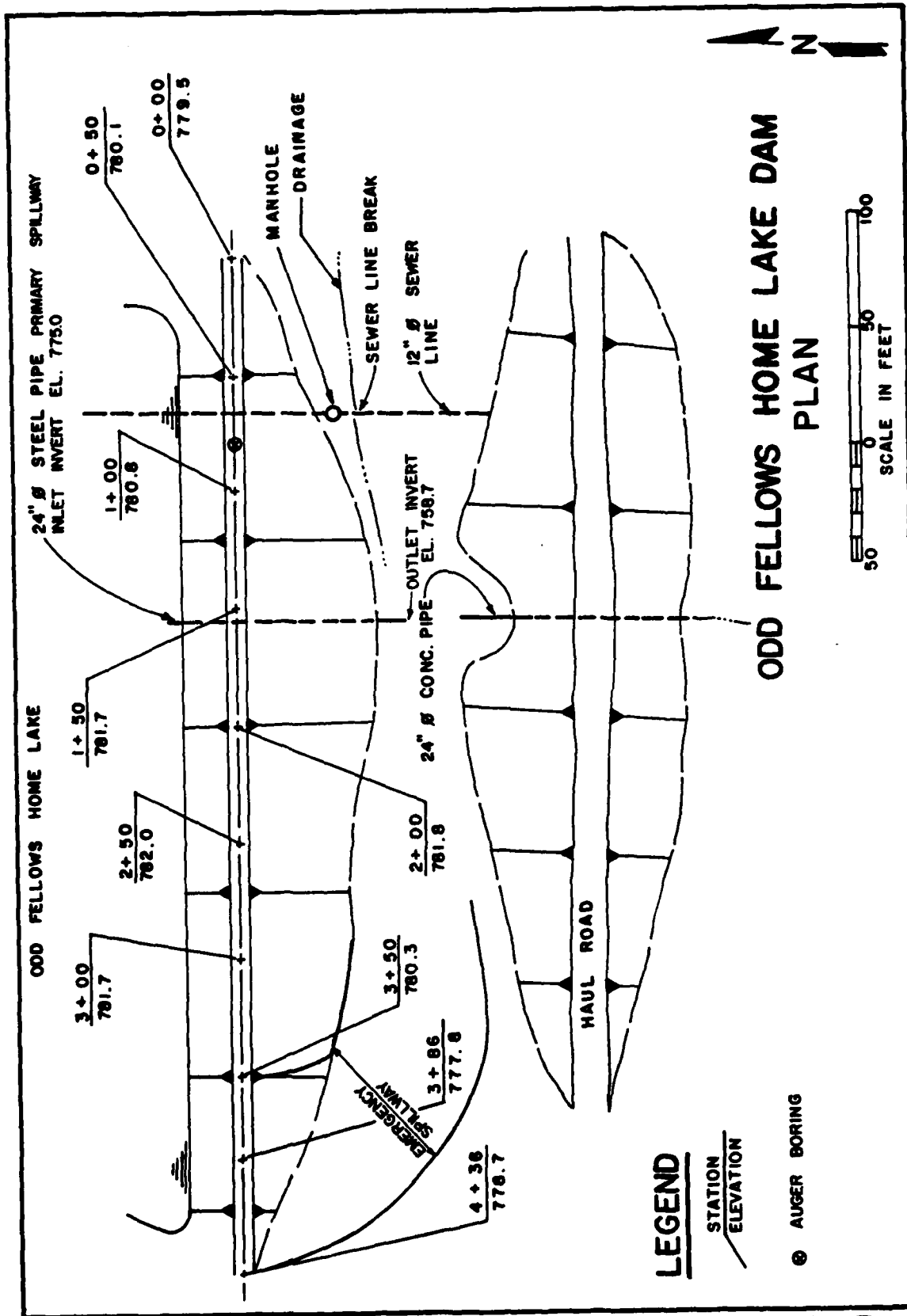
(4) The sewer line near the left abutment should be repaired to eliminate leakage of sewage.

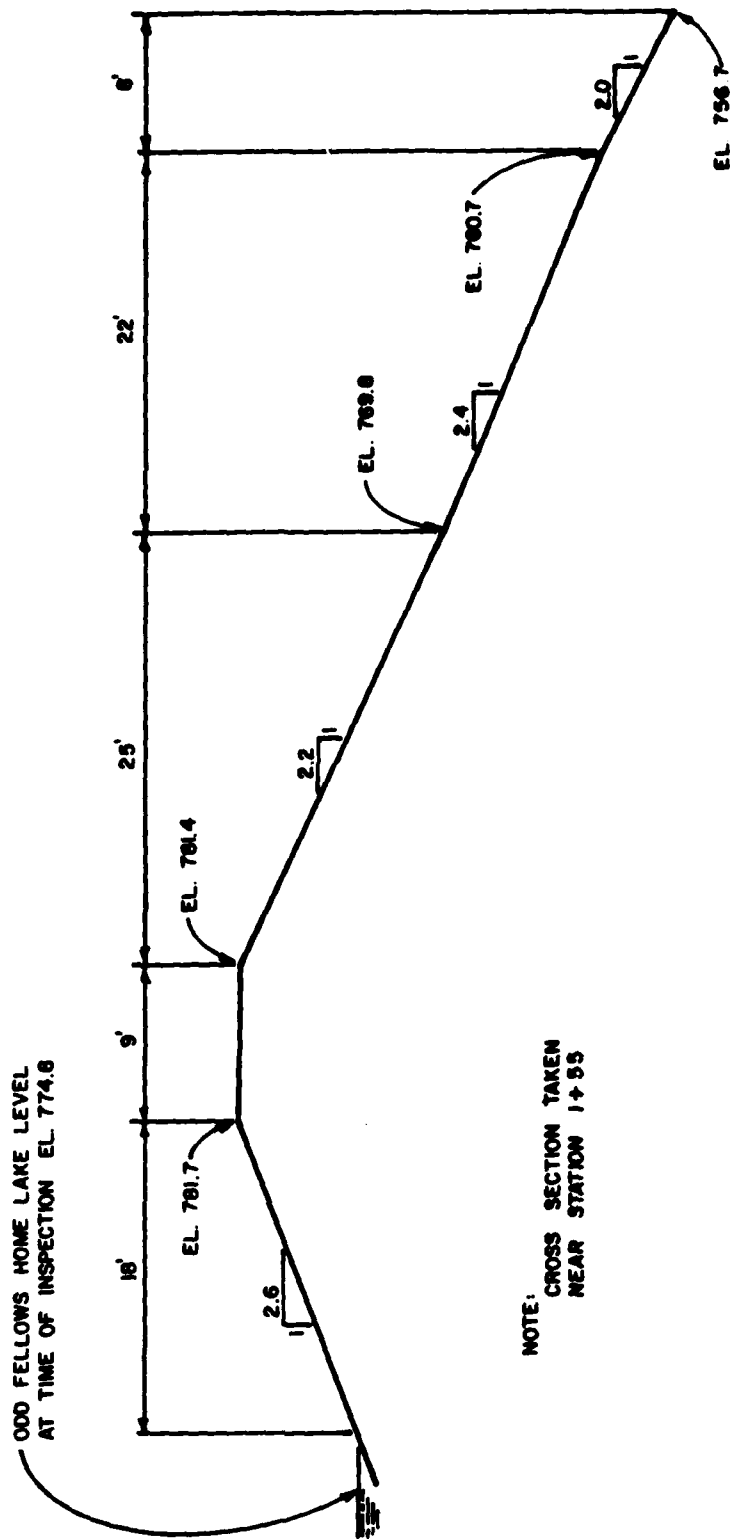
(5) A trash rack should be added to the primary spillway inlet.

(6) Seepage and stability analysis should be performed.

(7) A detailed inspection of the dam should be made periodically. This inspection should include measurement of seepage flows and analyzing water samples taken from the seep and lake. More frequent inspections may be required if additional deficiencies are observed or the severity of the reported deficiencies increase.

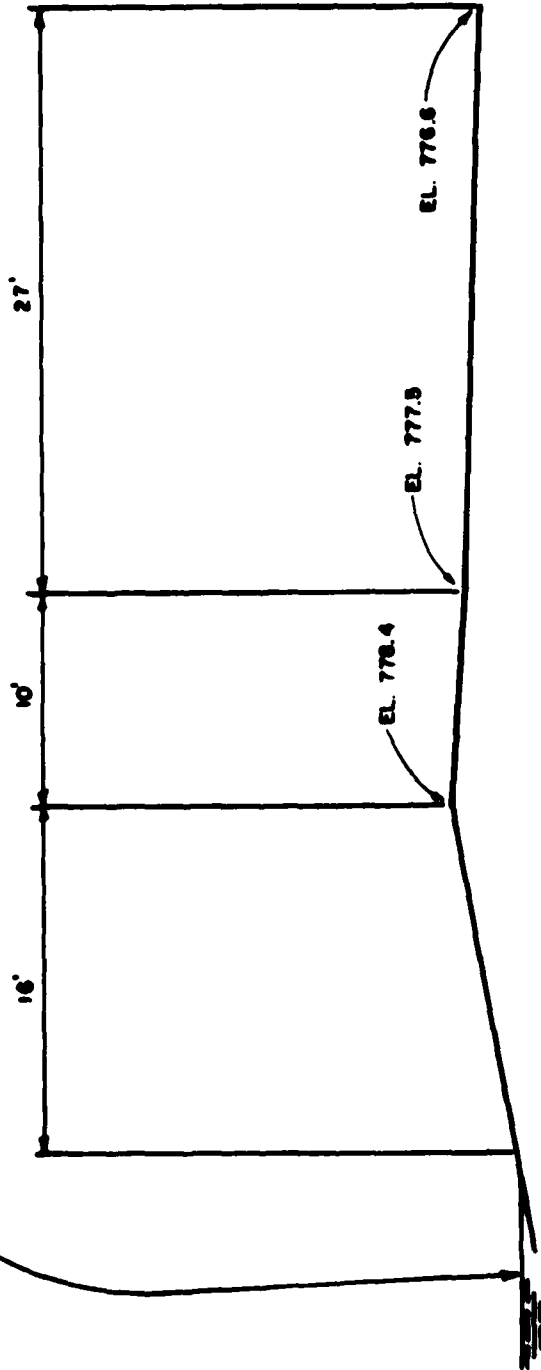






ODD FELLOWS HOME LAKE DAM DAM CROSS SECTION

ODD FELLOWS HOME LAKE LEVEL
AT TIME OF INSPECTION EL. 774.8



NOTE: CROSS SECTION TAKEN
NEAR STATION 4 + 00

ODD FELLOWS HOME LAKE DAM EMERGENCY SPILLWAY PROFILE

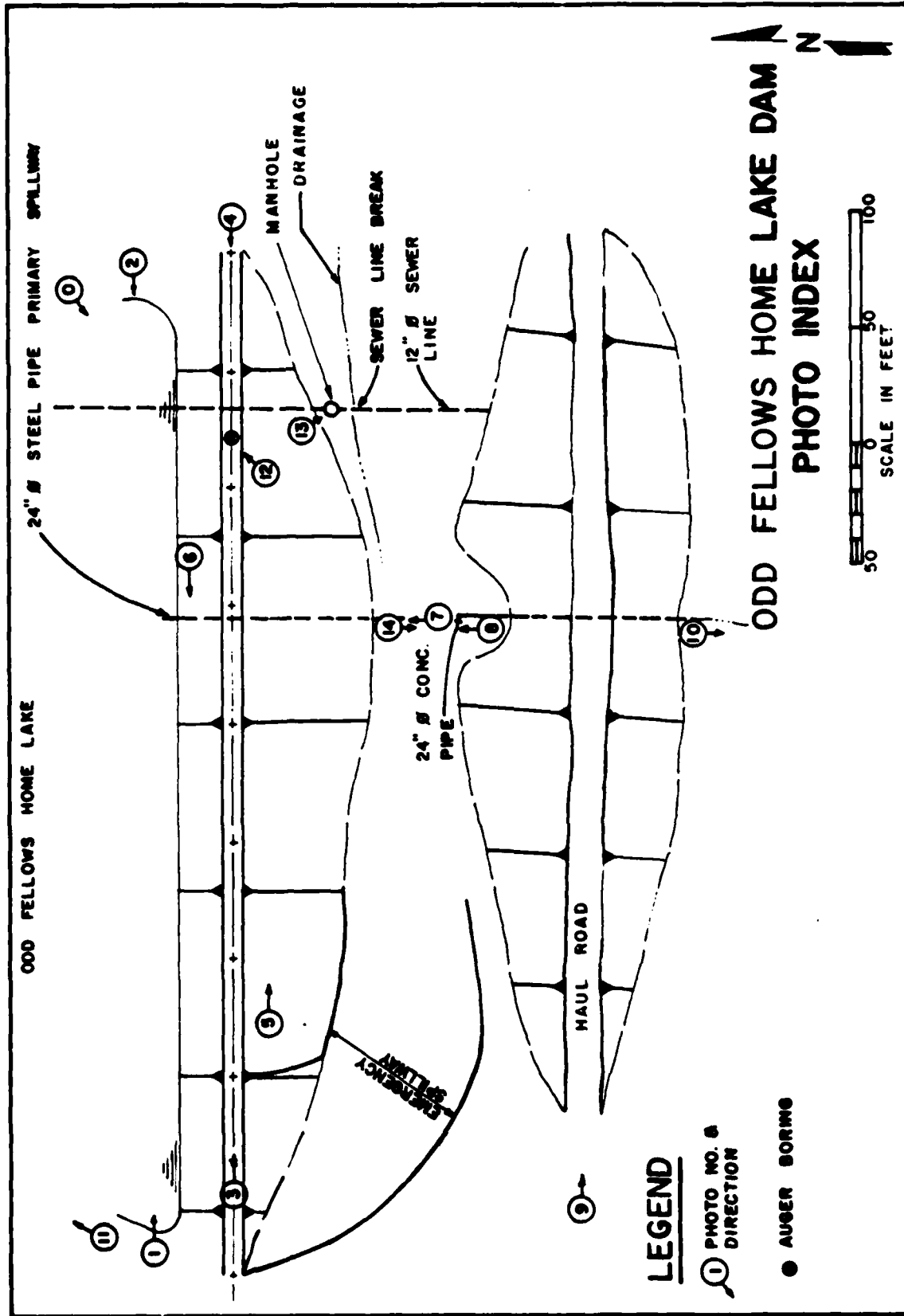


PLATE 6



PHOTO 1: FACE OF DAM LOOKING EAST



PHOTO 2: FACE OF DAM LOOKING WEST



PHOTO 3: CREST OF DAM LOOKING EAST



PHOTO 4: CREST OF DAM LOOKING WEST



PHOTO 5: TYPICAL VIEW OF BACK SLOPE OF DAM



PHOTO 6: PRIMARY SPILLWAY INLET



PHOTO 7: PRIMARY SPILLWAY OUTLET



PHOTO 8: OUTLET OF PRIMARY SPILLWAY AND INLET TO
PIPE THROUGH LOWER EMBANKMENT



PHOTO 9: OVERVIEW OF LOWER EMBANKMENT

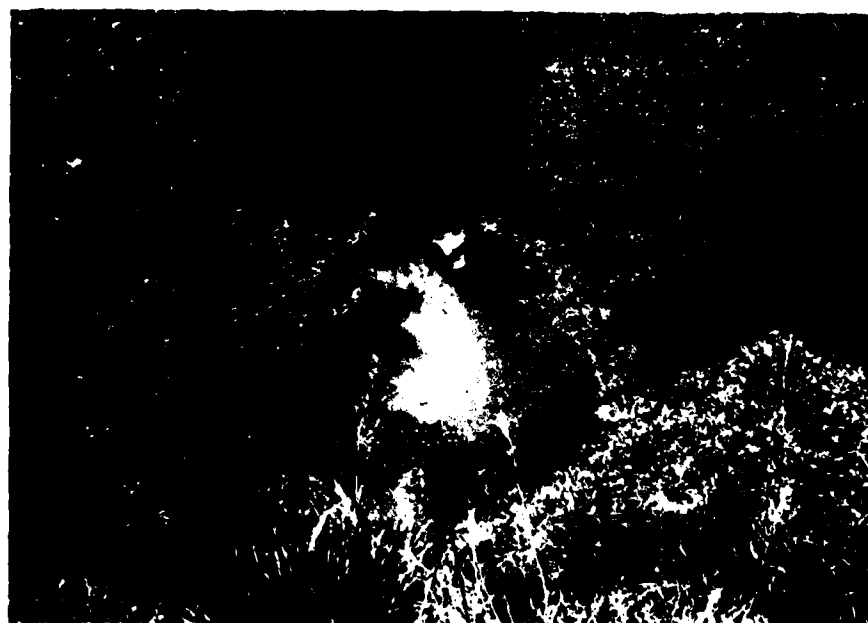


PHOTO 10: CHANNEL BELOW LOWER EMBANKMENT



PHOTO 11: UPPER END OF ODD FELLOWS HOME LAKE

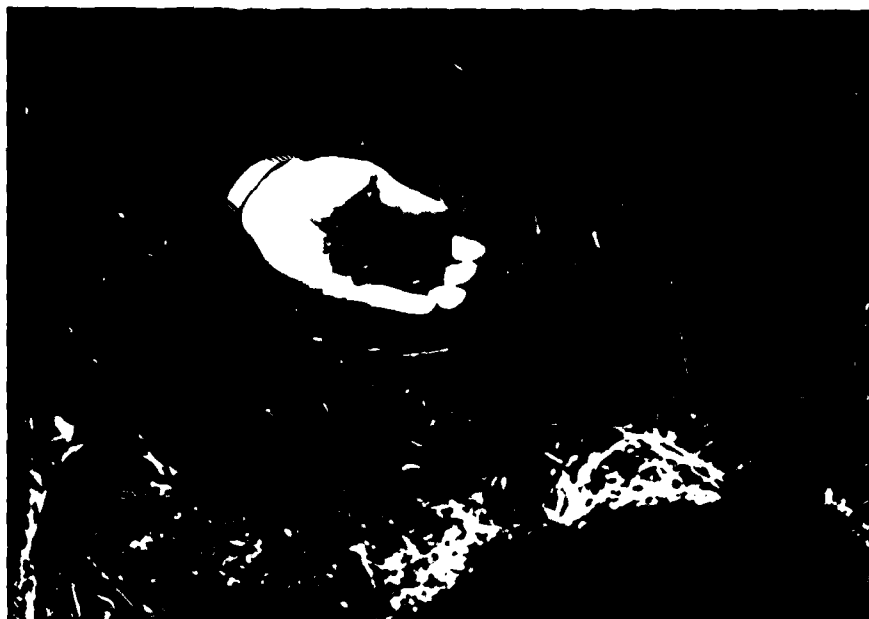


PHOTO 12: SAMPLE OF EMBANKMENT MATERIAL



PHOTO 13: SEWER MANHOLE ON DOWNSTREAM SIDE OF DAM

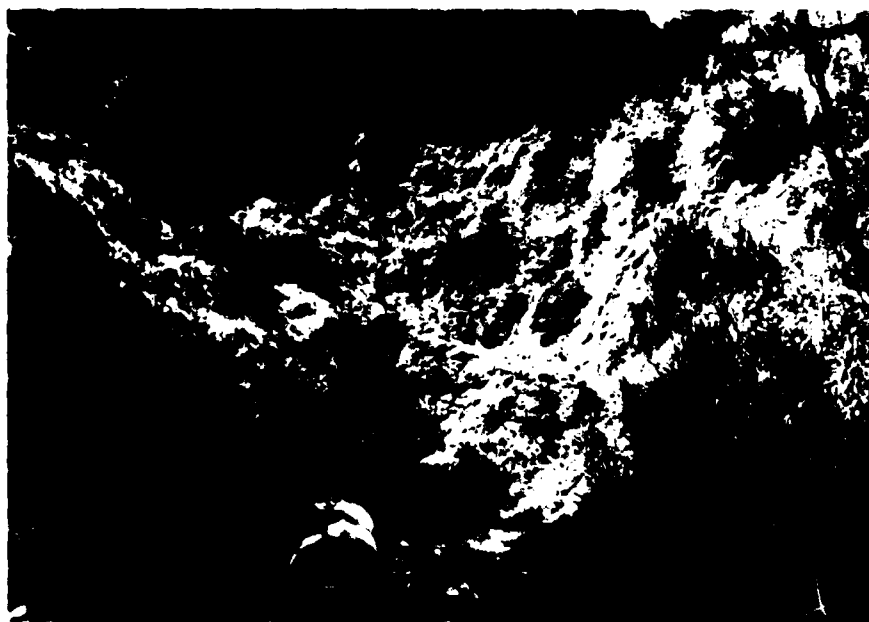


PHOTO 14: EROSION AT LOWER EMBANKMENT

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).

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33" (HMR-33). Reduction factors were not applied. The rainfall distribution for the 48-hour PMP storm was determined according to the procedures outlined in HMR-33 and EM 1110-2-1411. The Kansas City, Missouri rainfall distribution (15 min. interval - 48 hours duration), as provided by the St. Louis District, Corp 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. 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 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 pipe invert elevation of the primary spillway at elevation 775.0 feet m.s.l. in accordance with antecedent storm conditions preceding the one percent probability and probable maximum storms outlined by the U.S. Army Corps of Engineers, St. Louis District (5). 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 spillways is shown in Table 4. The flow over the crest of the dam and emergency spillway was determined using the non-level dam crest option (\$L and \$V cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir. The flow through the primary spillway was determined from the orifice flow equation and nomographs for partial flow in the pipe.

The result of the routing analyses indicates that 10 percent of the PMF will not overtop 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)	487 acres	
Hydraulic Length of Watercourse (L)	7,400 feet	
Hydrologic Soil Cover Complex Number (CN')	87 (AMC III)	73 (AMC II)
Average Watershed Land Slope (Y)	1.68%	
Lag Time (L _g)	1.49 hours (AMC III)	2.45 hours (AMC II)
Time of concentration (T _c)	2.48 hours (AMC III)	4.08 hours (AMC II)
Duration (D)	20 min. (AMC III)	33 min. (AMC II)
	(use 15 minutes in each case)	

<u>Time (Min.) *</u>	<u>Discharge (cfs) *</u>	
	<u>AMC II</u>	<u>AMC III</u>
0	0	16
15	17	46
30	32	94
45	52	157
60	79	205
75	108	226
90	131	226
105	146	206
120	153	179
135	153	142
150	148	104
165	137	81
180	125	63
195	110	50
210	92	39

* From HEC-1 computer output

TABLE 1
(Continued)

FORMULAS USED:

$$L_s = \frac{t^{0.8} \times (S + 1)^{0.7}}{1,900 \times Y^{0.5}} \quad (4)$$

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

$$T_c = L_s / 0.6$$

$$D = 0.133 T_c$$

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>
PMF	48	34.44	32.71	1.73
1% Probability	48	6.00	3.09	2.91

Additional Data:

- 1) The soil associations in this watershed are Macksburg, Sibley, and Sharpsburg (3).
100 percent of drainage area in hydrologic soil group B.
30 percent of the land use was urban.
60 percent of the land use was cropland.
10 percent of the land use was timberland (2 and 4).
- 2) SCS Runoff Curve CN = 87 (AMC III) for the PMF.
- 3) SCS Runoff Curve CN = 73 (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>
*775.0	6.3	32	0
**777.8	6.8	50	58
***779.5	9.0	64	377

*Primary spillway pipe invert elevation
 **Emergency spillway crest elevation
 ***Top of dam elevation

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

TABLE 4

SPILLWAY RATING CURVE

<u>Reservoir Elevation (ft-msl)</u>	<u>Primary Spillway Discharge (cfs)</u>	<u>Emergency Spillway Discharge (cfs)</u>	<u>Total Spillway Discharge (cfs)</u>
775.0	0	0	0
776.0	5	0	5
777.0	55	0	55
*777.8	58	0	58
778.0	58	2	60
**779.5	61	316	377

*Emergency Spillway Crest Elevation

**Top of Dam Elevation

METHOD USED:

Primary spillway release rates were based on the discharge calculated for flow through the pipe using the orifice equation:

$$Q = 2a[2gH]^{1/2}$$

where:

c = 0.45 = coefficient of discharge

a = 3.14 sq. ft₂ = net area of orifice

g = 32.2 ft/sec² = gravitational acceleration

H = difference between the energy gradient elevation upstream and the downstream tailwater elevation (6).

Discharge rates for a partially filled outlet pipe were determined by nomographs for pipe culverts with inlet control (7).

Emergency spillway releases were computed by HEC-1 from spillway geometry data input on \$L and \$V cards. The following equations were used in calculating the emergency spillway discharge:

$$d_c = 2/3 (H_m + 1/4 \Delta Y)$$

$$A = 1/2 T (2d_c - \Delta Y)$$

$$Q = (A^3 g/T)^{0.5}$$

where:

d_c = critical depth (feet)

H_m = available specific energy which is taken to be the height of the water surface in the reservoir above the bottom of the section (feet)

ΔY = change in elevation across the section (feet)

A = flow area (sq. ft.)

T = top width (feet)

Q = flow (cfs)

$g = 32.2 \text{ ft/sec}^2$ = acceleration due to gravity.

TABLE 5

RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (CFS)	Peak Lake Elevation (ft.-MSL)	Total Storage (AC.-FT.)	Peak Outflow (CFS)	Depth (ft.) Over Top of Dam
-	0	*775.0	32	0	-
0.10	300	779.3	61	293	0
0.50	1,498	780.7	72	1,498	1.2
1.00	2,996	781.5	79	2,996	2.0

* Primary spillway pipe invert elevation

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- (6) Horace W. King and Ernest F. Brater, Handbook of Hydraulics, Sixth Edition, McGraw Hill Book Company, 1976.
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- (9) Mary H. McCracken, Missouri Division of Geological Survey, Geologic Map of Missouri, 1961.

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MISSOURI DAM INSPECTION PROGRAM
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100 ELLIOTT LANE DAM

THE FELLOWS LANE DAM

FOR SPECIFICATION

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5. 4. 5. 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. 8

END-OF-PERIOD FLOW

| | LOSS | COMP Q | 90-DA | HR-MN | PERIOD | WASH |
|-----|------|--------|-------|-------|--------|------|
| CNC | | | | | | |

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 2101 2102 2103 2104 2105 2106 2107 2108 2109 2110 2111 2112 2113 2114 2115 2116 2117 2118 2119 2120 2121 2122 2123 2124 2125 2126 2127 2128 2129 2130 2131 2132 2133 2134 2135 2136 2137 2138 2139 2140 2141 2142 2143 2144 2145 2146 2147 2148 2149 2150 2151 2152 2153 2154 2155 2156 2157 2158 2159 2160 2161 2162 2163 2164 2165 2166 2167 2168 2169 2170 2171 2172 2173 2174 2175 2176 2177 2178 2179 2180 2181 2182 2183 2184 2185 2186 2187 2188 2189 2190 2191 2192 2193 2194 2195 2196 2197 2198 2199 2200 2201 2202 2203 2204 2205 2206 2207 2208 2209 2210 2211 2212 2213 2214 2215 2216 2217 2218 2219 2220 2221 2222 2223 2224 2225 2226 2227 2228 2229 2230 2231 2232 2233 2234 2235 2236 2237 2238 2239 2240 2241 2242 2243 2244 2245 2246 2247 2248 2249 2250 2251 2252 2253 2254 2255 2256 2257 2258 2259 2260 2261 2262 2263 2264 2265 2266 2267 2268 2269 2270 2271 2272 2273 2274 2275 2276 2277 2278 2279 2280 2281 2282 2283 2284 2285 2286 2287 2288 2289 2290 2291 2292 2293 2294 2295 2296 2297 2298 2299 2300 2301 2302 2303 2304 2305 2306 2307 2308 2309 2310 2311 2312 2313 2314 2315 2316 2317 2318 2319 2320 2321 2322 2323 2324 2325 2326 2327 2328 2329 2330 2331 2332 2333 2334 2335 2336 2337 2338 2339 2340 2341 2342 2343 2344 2345 2346 2347 2348 2349 2350 2351 2352 2353 2354 2355 2356 2357 2358 2359 2360 2361 2362 2363 2364 2365 2366 2367 2368 2369 2370 2371 2372 2373 2374 2375 2376 2377 2378 2379 2380 2381 2382 2383 2384 2385 2386 2387 2388 2389 2390 2391 2392 2393 2394 2395 2396 2397 2398 2399 2400 2401 2402 2403 2404 2405 2406 2407 2408 2409 2410 2411 2412 2413 2414 2415 2416 2417 2418 2419 2420 2421 2422 2423 2424 2425 2426 2427 2428 2429 2430 2431 2432 2433 2434 2435 2436 2437 2438 2439 2440 2441 2442 2443 2444 2445 2446 2447 2448 2449 2450 2451 2452 2453 2454 2455 2456 2457 2458 2459 2460 2461 2462 2463 2464 2465 2466 2467 2468 2469 2470 2471 2472 2473 2474 2475 2476 2477 2478 2479 2480 2481 2482 2483 2484 2485 2486 2487 2488 2489 2490 2491 2492 2493 2494 2495 2496 2497 2498 2499 2500 2501 2502 2503 2504 2505 2506 2507 2508 2509 2510 2511 2512 2513 2514 2515 2516 2517 2518 2519 2520 2521 2522 2523 2524 2525 2526 2527 2528 2529 2530 2531 2532 2533 2534 2535 2536 2537 2538 2539 2540 2541 2542 2543 2544 2545 2546 2547 2548 2549 2550 2551 2552 2553 2554 2555 2556 2557 2558 2559 2560 2561 2562 2563 2564 2565 2566 2567 2568 2569 2570 2571 2572 2573 2574 2575 2576 2577 2578 2579 2580 2581 2582 2583 2584 2585 2586 2587 2588 2589 2590 2591 2592 2593 2594 2595 2596 2597 2598 2599 2600 2601 2602 2603 2604 2605 2606 2607 2608 2609 2610 2611 2612 2613 2614 2615 2616 2617 2618 2619 2620 2621 2622 2623 2624 2625 2626 2627 2628 2629 2630 2631 2632 2633 2634 2635 2636 2637 2638 2639 2640 2641 2642 2643 2644 2645 2646 2647 2648 2649 2650 2651 2652 2653 2654 2655 2656 2657 2658 2659 2660 2661 2662 2663 2664 2665 2666 2667 2668 2669 2670 2671 2672 2673 2674 2675 2676 2677 2678 2679 2680 2681 2682 2683 2684 2685 2686 2687 2688 2689 2690 2691 2692 2693 2694 2695 2696 2697 2698 2699 2700 2701 2702 2703 2704 2705 2706 2707 2708 2709 2710 2711 2712 2713 2714 2715 2716 2717 2718 2719 2720 2721 2722 2723 2724 2725 2726 2727 2728 2729 2730 2731 2732 2733 2734 2735 2736 2737 2738 2739 2740 2741 2742 2743 2744 2745 2746 2747 2748 2749 2750 2751 2752 2753 2754 2755 2756 2757 2758 2759 2760 2761 2762 2763 2764 2765 2766 2767 2768 2769 2770 2771 2772 2773 2774 2775 2776 2777 2778 2779 2780 2781 2782 2783 2784 2785 2786 2787 2788 2789 2790 2791 2792 2793 2794 2795 2796 2797 2798 2799 2800 2801 2802 2803 2804 2805 2806 2807 2808 2809 2810 2811 2812 2813 2814 2815 2816 2817 2818 2819 2820 2821 2822 2823 2824 2825

Figure 1. The effect of the concentration of the inhibitor on the rate of polymerization of α -methylstyrene in the presence of SnCl_4 at 25°C . The concentration of α -methylstyrene was 1.0 mol/L, and the concentration of SnCl_4 was 0.01 mol/L. The concentration of the inhibitor was 0.001 mol/L (○), 0.002 mol/L (□), 0.004 mol/L (△), 0.006 mol/L (◇), 0.008 mol/L (▽), 0.01 mol/L (×), 0.02 mol/L (●), 0.04 mol/L (◐), 0.06 mol/L (◑), 0.08 mol/L (◒), 0.1 mol/L (◓), 0.2 mol/L (◔), 0.4 mol/L (◕), 0.6 mol/L (◖), 0.8 mol/L (◗), 1.0 mol/L (◘).

1. The first part of the paper is devoted to the study of the properties of the function $f(x)$ defined by the equation $f(x) = \int_0^x f(t) dt$. It is shown that $f(x)$ is a continuous function and that it satisfies the functional equation $f(x+y) = f(x) + f(y)$. The function $f(x)$ is also shown to be differentiable and its derivative is found to be $f'(x) = f(x)$. This implies that $f(x) = Ce^x$ for some constant C . The value of C is determined by the initial condition $f(0) = 1$, which gives $C = 1$. Therefore, the function $f(x)$ is the exponential function $f(x) = e^x$.

UNIT HYDROGRAPH 32 END OF PERIOD ORIGINATES, TC= 0.00 HOURS, LAG= 1.49 VOL= 1.00

START= 0.00 QPCSN= 0.00 RTT= 1.00

12. 46. 94. 157. 204. 226. 206. 179. 142.
 104. 81. 63. 50. 39. 23. 18. 14. 11.
 8. 7. 5. 4. 3. 2. 1. 1. 1.
 2. 0.

| NO. DA | | MR. MN | PERIOD | RAIN | EXCS | LOSS | COMP Q | 10.0A | HR. MN | PERIOD | RAIN | EXCS | LOSS | COMP Q |
|--------|-------|--------|--------|------|------|------|--------|-------|--------|--------|------|------|------|--------|
| 1.01 | 15 | 1 | 1 | .00 | 0.00 | .00 | 0. | 1.02 | .15 | 97 | .04 | .03 | .01 | 9. |
| 1.01 | 30 | 2 | 2 | .00 | 0.00 | .00 | 0. | 1.02 | .30 | 98 | .04 | .03 | .01 | 10. |
| 1.01 | 45 | 3 | 3 | .00 | 0.00 | .00 | 0. | 1.02 | .45 | 99 | .04 | .03 | .01 | 13. |
| 1.01 | 1.00 | 4 | 4 | .00 | 0.00 | .00 | 0. | 1.02 | 1.00 | 100 | .04 | .03 | .01 | 17. |
| 1.01 | 1.15 | 5 | 5 | .00 | 0.00 | .00 | 0. | 1.02 | 1.15 | 101 | .04 | .03 | .01 | 24. |
| 1.01 | 1.30 | 6 | 6 | .00 | 0.00 | .00 | 0. | 1.02 | 1.30 | 102 | .04 | .03 | .01 | 30. |
| 1.01 | 1.45 | 7 | 7 | .00 | 0.00 | .00 | 0. | 1.02 | 1.45 | 103 | .04 | .04 | .01 | 37. |
| 1.01 | 2.00 | 8 | 8 | .00 | 0.00 | .00 | 0. | 1.02 | 2.00 | 104 | .04 | .04 | .01 | 44. |
| 1.01 | 2.15 | 9 | 9 | .00 | 0.00 | .00 | 0. | 1.02 | 2.15 | 105 | .04 | .04 | .01 | 49. |
| 1.01 | 2.30 | 10 | 10 | .00 | 0.00 | .00 | 0. | 1.02 | 2.30 | 106 | .04 | .04 | .01 | 54. |
| 1.01 | 2.45 | 11 | 11 | .00 | 0.00 | .00 | 0. | 1.02 | 2.45 | 107 | .04 | .04 | .01 | 57. |
| 1.01 | 3.00 | 12 | 12 | .00 | 0.00 | .00 | 0. | 1.02 | 3.00 | 108 | .04 | .04 | .01 | 60. |
| 1.01 | 3.15 | 13 | 13 | .00 | 0.00 | .00 | 0. | 1.02 | 3.15 | 109 | .04 | .04 | .01 | 62. |
| 1.01 | 3.30 | 14 | 14 | .00 | 0.00 | .00 | 0. | 1.02 | 3.30 | 110 | .04 | .04 | .01 | 64. |
| 1.01 | 3.45 | 15 | 15 | .00 | 0.00 | .00 | 0. | 1.02 | 3.45 | 111 | .04 | .04 | .01 | 65. |
| 1.01 | 4.00 | 16 | 16 | .00 | 0.00 | .00 | 0. | 1.02 | 4.00 | 112 | .04 | .04 | .00 | 66. |
| 1.01 | 4.15 | 17 | 17 | .00 | 0.00 | .00 | 0. | 1.02 | 4.15 | 113 | .04 | .04 | .00 | 67. |
| 1.01 | 4.30 | 18 | 18 | .00 | 0.00 | .00 | 0. | 1.02 | 4.30 | 114 | .04 | .04 | .00 | 68. |
| 1.01 | 4.45 | 19 | 19 | .00 | 0.00 | .00 | 0. | 1.02 | 4.45 | 115 | .04 | .04 | .00 | 68. |
| 1.01 | 5.00 | 20 | 20 | .00 | 0.00 | .00 | 0. | 1.02 | 5.00 | 116 | .04 | .04 | .00 | 69. |
| 1.01 | 5.15 | 21 | 21 | .00 | 0.00 | .00 | 0. | 1.02 | 5.15 | 117 | .04 | .04 | .00 | 69. |
| 1.01 | 5.30 | 22 | 22 | .00 | 0.00 | .00 | 0. | 1.02 | 5.30 | 118 | .04 | .04 | .00 | 70. |
| 1.01 | 5.45 | 23 | 23 | .00 | 0.00 | .00 | 0. | 1.02 | 5.45 | 119 | .04 | .04 | .00 | 70. |
| 1.01 | 6.00 | 24 | 24 | .00 | 0.00 | .00 | 0. | 1.02 | 6.00 | 120 | .04 | .04 | .00 | 70. |
| 1.01 | 6.15 | 25 | 25 | .00 | 0.00 | .01 | 0. | 1.02 | 6.15 | 121 | .19 | .18 | .02 | 73. |
| 1.01 | 6.30 | 26 | 26 | .01 | 0.00 | .01 | 0. | 1.02 | 6.30 | 122 | .19 | .18 | .02 | 80. |
| 1.01 | 6.45 | 27 | 27 | .01 | 0.00 | .01 | 0. | 1.02 | 6.45 | 123 | .19 | .18 | .02 | 83. |
| 1.01 | 7.00 | 28 | 28 | .01 | 0.00 | .01 | 0. | 1.02 | 7.00 | 124 | .19 | .18 | .02 | 115. |
| 1.01 | 7.15 | 29 | 29 | .01 | 0.00 | .01 | 0. | 1.02 | 7.15 | 125 | .19 | .18 | .01 | 144. |
| 1.01 | 7.30 | 30 | 30 | .01 | 0.00 | .01 | 0. | 1.02 | 7.30 | 126 | .19 | .18 | .01 | 176. |
| 1.01 | 7.45 | 31 | 31 | .01 | 0.00 | .01 | 0. | 1.02 | 7.45 | 127 | .19 | .18 | .01 | 209. |
| 1.01 | 8.00 | 32 | 32 | .01 | 0.00 | .01 | 0. | 1.02 | 8.00 | 128 | .19 | .18 | .01 | 258. |
| 1.01 | 8.15 | 33 | 33 | .01 | 0.00 | .01 | 0. | 1.02 | 8.15 | 129 | .19 | .18 | .01 | 265. |
| 1.01 | 8.30 | 34 | 34 | .01 | 0.00 | .01 | 0. | 1.02 | 8.30 | 130 | .19 | .18 | .01 | 286. |
| 1.01 | 8.45 | 35 | 35 | .01 | 0.00 | .01 | 0. | 1.02 | 8.45 | 131 | .19 | .19 | .01 | 302. |
| 1.01 | 9.00 | 36 | 36 | .01 | 0.00 | .01 | 0. | 1.02 | 9.00 | 132 | .19 | .19 | .01 | 315. |
| 1.01 | 9.15 | 37 | 37 | .01 | 0.00 | .01 | 0. | 1.02 | 9.15 | 133 | .19 | .19 | .01 | 325. |
| 1.01 | 9.30 | 38 | 38 | .01 | 0.00 | .01 | 0. | 1.02 | 9.30 | 134 | .19 | .19 | .01 | 333. |
| 1.01 | 9.45 | 39 | 39 | .01 | 0.00 | .01 | 0. | 1.02 | 9.45 | 135 | .19 | .19 | .01 | 340. |
| 1.01 | 10.00 | 40 | 40 | .01 | 0.00 | .01 | 0. | 1.02 | 10.00 | 136 | .19 | .19 | .01 | 345. |
| 1.01 | 10.15 | 41 | 41 | .01 | 0.00 | .01 | 0. | 1.02 | 10.15 | 137 | .19 | .19 | .01 | 350. |
| 1.01 | 10.30 | 42 | 42 | .01 | 0.00 | .01 | 0. | 1.02 | 10.30 | 138 | .19 | .19 | .01 | 354. |
| 1.01 | 10.45 | 43 | 43 | .01 | 0.00 | .01 | 0. | 1.02 | 10.45 | 139 | .19 | .19 | .01 | 357. |
| 1.01 | 11.00 | 44 | 44 | .01 | 0.00 | .01 | 0. | 1.02 | 11.00 | 140 | .19 | .19 | .01 | 359. |
| 1.01 | 11.15 | 45 | 45 | .01 | 0.00 | .01 | 0. | 1.02 | 11.15 | 141 | .19 | .19 | .01 | 361. |
| 1.01 | 11.30 | 46 | 46 | .01 | 0.00 | .01 | 1. | 1.02 | 11.30 | 142 | .19 | .19 | .01 | 363. |
| 1.01 | 11.45 | 47 | 47 | .01 | 0.00 | .01 | 1. | 1.02 | 11.45 | 143 | .19 | .19 | .01 | 365. |
| 1.01 | 12.00 | 48 | 48 | .01 | 0.00 | .01 | 1. | 1.02 | 12.00 | 144 | .19 | .19 | .01 | 366. |
| 1.01 | 12.15 | 49 | 49 | .05 | .01 | .04 | 2. | 1.02 | 12.15 | 145 | .62 | .61 | .01 | 374. |
| 1.01 | 12.30 | 50 | 50 | .05 | .01 | .04 | 3. | 1.02 | 12.30 | 146 | .62 | .61 | .01 | 394. |

| | | | | | | | | | | | | | | | | |
|------|-------|-----|-----|-----|-----|-----|-----|-----|-----|------|-------|-----|------|------|-----|-------|
| 1-01 | 10.00 | .00 | .01 | .00 | .01 | .00 | .01 | .00 | .01 | .02 | 10.00 | 136 | .19 | .19 | .01 | .45. |
| 1-01 | 10.00 | .01 | .01 | .00 | .01 | .00 | .01 | .00 | .01 | 1.02 | 10.15 | 137 | .19 | .19 | .01 | 0. |
| 1-01 | 10.30 | .02 | .01 | .00 | .01 | .00 | .01 | .00 | .01 | 1.02 | 10.30 | 138 | .19 | .19 | .01 | 0.4. |
| 1-01 | 10.45 | .03 | .01 | .00 | .01 | .00 | .01 | .00 | .01 | 1.02 | 10.45 | 139 | .19 | .19 | .01 | 357. |
| 1-01 | 11.00 | .04 | .01 | .00 | .01 | .00 | .01 | .00 | .01 | 1.02 | 11.00 | 140 | .19 | .19 | .01 | 359. |
| 1-01 | 11.15 | .05 | .01 | .00 | .01 | .00 | .01 | .00 | .01 | 1.02 | 11.15 | 141 | .19 | .19 | .01 | 361. |
| 1-01 | 11.30 | .06 | .01 | .00 | .01 | .00 | .01 | .00 | .01 | 1.02 | 11.30 | 142 | .19 | .19 | .01 | 363. |
| 1-01 | 11.45 | .07 | .01 | .00 | .01 | .00 | .01 | .00 | .01 | 1.02 | 11.45 | 143 | .19 | .19 | .01 | 365. |
| 1-01 | 12.00 | .08 | .01 | .00 | .01 | .00 | .01 | .00 | .01 | 1.02 | 12.00 | 144 | .19 | .19 | .01 | 366. |
| 1-01 | 12.15 | .09 | .05 | .01 | .04 | .01 | .04 | .01 | .04 | 1.02 | 12.15 | 145 | .62 | .61 | .01 | 374. |
| 1-01 | 12.30 | .50 | .05 | .01 | .04 | .01 | .04 | .01 | .04 | 1.02 | 12.30 | 146 | .62 | .61 | .01 | 394. |
| 1-01 | 12.45 | .51 | .05 | .01 | .03 | .01 | .03 | .01 | .03 | 1.02 | 12.45 | 147 | .62 | .61 | .01 | 434. |
| 1-01 | 13.00 | .52 | .05 | .01 | .03 | .01 | .03 | .01 | .03 | 1.02 | 13.00 | 148 | .62 | .61 | .01 | 500. |
| 1-01 | 13.15 | .53 | .06 | .02 | .04 | .01 | .04 | .01 | .04 | 1.02 | 13.15 | 149 | .75 | .73 | .01 | 589. |
| 1-01 | 13.30 | .54 | .06 | .02 | .04 | .01 | .04 | .01 | .04 | 1.02 | 13.30 | 150 | .75 | .74 | .01 | 690. |
| 1-01 | 13.45 | .55 | .06 | .02 | .04 | .01 | .04 | .01 | .04 | 1.02 | 13.45 | 151 | .75 | .74 | .01 | 797. |
| 1-01 | 14.00 | .56 | .06 | .03 | .03 | .03 | .03 | .03 | .03 | 1.02 | 14.00 | 152 | .75 | .74 | .01 | 903. |
| 1-01 | 14.15 | .57 | .07 | .03 | .03 | .03 | .03 | .03 | .03 | 1.02 | 14.15 | 153 | .93 | .92 | .01 | 1007. |
| 1-01 | 14.30 | .58 | .07 | .04 | .03 | .04 | .03 | .04 | .03 | 1.02 | 14.30 | 154 | .93 | .92 | .01 | 1104. |
| 1-01 | 14.45 | .59 | .07 | .04 | .03 | .04 | .03 | .04 | .03 | 1.02 | 14.45 | 155 | .93 | .92 | .01 | 1195. |
| 1-01 | 15.00 | .60 | .07 | .04 | .03 | .04 | .03 | .04 | .03 | 1.02 | 15.00 | 156 | .93 | .93 | .01 | 1284. |
| 1-01 | 15.15 | .61 | .07 | .04 | .03 | .04 | .03 | .04 | .03 | 1.02 | 15.15 | 157 | .94 | .94 | .01 | 1372. |
| 1-01 | 15.30 | .62 | .15 | .09 | .05 | .09 | .05 | .09 | .05 | 1.02 | 15.30 | 158 | 1.89 | 1.88 | .01 | 1469. |
| 1-01 | 15.45 | .63 | .41 | .29 | .12 | .29 | .12 | .29 | .12 | 1.02 | 15.45 | 159 | 5.27 | 5.27 | .02 | 1636. |
| 1-01 | 16.00 | .64 | .10 | .08 | .03 | .08 | .03 | .08 | .03 | 1.02 | 16.00 | 160 | 1.32 | 1.32 | .00 | 1884. |
| 1-01 | 16.15 | .65 | .07 | .05 | .02 | .05 | .02 | .05 | .02 | 1.02 | 16.15 | 161 | .87 | .87 | .00 | 2217. |
| 1-01 | 16.30 | .66 | .07 | .05 | .01 | .05 | .01 | .05 | .01 | 1.02 | 16.30 | 162 | .87 | .87 | .00 | 2594. |
| 1-01 | 16.45 | .67 | .07 | .05 | .01 | .05 | .01 | .05 | .01 | 1.02 | 16.45 | 163 | .87 | .87 | .00 | 2872. |
| 1-01 | 17.00 | .68 | .07 | .05 | .01 | .05 | .01 | .05 | .01 | 1.02 | 17.00 | 164 | .87 | .87 | .00 | 2996. |
| 1-01 | 17.15 | .69 | .05 | .04 | .01 | .04 | .01 | .04 | .01 | 1.02 | 17.15 | 165 | .68 | .68 | .00 | 2987. |
| 1-01 | 17.30 | .70 | .05 | .04 | .01 | .04 | .01 | .04 | .01 | 1.02 | 17.30 | 166 | .68 | .69 | .00 | 2866. |
| 1-01 | 17.45 | .71 | .05 | .04 | .01 | .04 | .01 | .04 | .01 | 1.02 | 17.45 | 167 | .68 | .68 | .00 | 2617. |
| 1-01 | 18.00 | .72 | .05 | .04 | .01 | .04 | .01 | .04 | .01 | 1.02 | 18.00 | 168 | .68 | .68 | .00 | 2447. |
| 1-01 | 18.15 | .73 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 18.15 | 169 | .06 | .06 | .00 | 2196. |
| 1-01 | 18.30 | .74 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 18.30 | 170 | .06 | .06 | .00 | 1990. |
| 1-01 | 18.45 | .75 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 18.45 | 171 | .06 | .06 | .00 | 1787. |
| 1-01 | 19.00 | .76 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 19.00 | 172 | .06 | .06 | .00 | 1576. |
| 1-01 | 19.15 | .77 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 19.15 | 173 | .06 | .06 | .00 | 1353. |
| 1-01 | 19.30 | .78 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 19.30 | 174 | .06 | .06 | .00 | 1137. |
| 1-01 | 19.45 | .79 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 19.45 | 175 | .06 | .06 | .00 | 939. |
| 1-01 | 20.00 | .80 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 20.00 | 176 | .06 | .06 | .00 | 766. |
| 1-01 | 20.15 | .81 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 20.15 | 177 | .06 | .06 | .00 | 621. |
| 1-01 | 20.30 | .82 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 20.30 | 178 | .06 | .06 | .00 | 506. |
| 1-01 | 20.45 | .83 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 20.45 | 179 | .06 | .06 | .00 | 420. |
| 1-01 | 21.00 | .84 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 21.00 | 180 | .06 | .06 | .00 | 353. |
| 1-01 | 21.15 | .85 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 21.15 | 181 | .06 | .06 | .00 | 302. |
| 1-01 | 21.30 | .86 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 21.30 | 182 | .06 | .06 | .00 | 211. |
| 1-01 | 21.45 | .87 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 21.45 | 183 | .06 | .06 | .00 | 229. |
| 1-01 | 22.00 | .88 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 22.00 | 184 | .06 | .06 | .00 | 205. |
| 1-01 | 22.15 | .89 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 22.15 | 185 | .06 | .06 | .00 | 186. |
| 1-01 | 22.30 | .90 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 22.30 | 186 | .06 | .06 | .00 | 171. |
| 1-01 | 22.45 | .91 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 22.45 | 187 | .06 | .06 | .00 | 159. |
| 1-01 | 23.00 | .92 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 23.00 | 188 | .06 | .06 | .00 | 149. |
| 1-01 | 23.15 | .93 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 23.15 | 189 | .06 | .06 | .00 | 142. |
| 1-01 | 23.30 | .94 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 23.30 | 190 | .06 | .06 | .00 | 135. |
| 1-01 | 23.45 | .95 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.02 | 23.45 | 191 | .06 | .06 | .00 | 131. |
| 1-02 | 0.00 | .96 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.03 | 0.00 | 192 | .06 | .06 | .00 | 128. |

SUM 34.44 32.71 1.73 63320.
(875.31 (831.31 (44.31 (1793.02)

PEAK 6-HOUR 24-HOUR 72-HOUR TOTAL VOLUME

| | |
|--------------|--------|
| TOTAL VOLUME | 63256. |
| | 1791. |
| | 32.22 |
| | 818.34 |
| | 1307. |
| | 1612. |

HYDROGRAPH ROUTING

| PRY | INAME | ISTAGE | TAUTO |
|------|--------|--------|--------|
| 0 | 1 | 0 | 0 |
| MP | | LSTR | |
| 0 | | | 0 |
| SK | STORA | ISPRAT | |
| GO | -775. | -1 | |
| 0.00 | 781.00 | | 782.00 |
| 2.00 | 63.00 | | 6.5 |

61.

613.

500.

| CAREA | EXPL |
|-------|------|
| 0.0 | 0.0 |

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100.

280

— 380 —

10

NATES

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|---|---|---|---|---|---|
| | . | . | . | . | . |
| . | . | . | . | . | . |
| . | . | . | . | . | . |

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

| OPERATION | STATION | AREA | PLAN | RATIOS APPLIED TO FLOWS | | | | | | |
|---------------|---------|------|------|-------------------------|---------|---------|---------|---------|---------|---------|
| | | | | RATIO 1 | RATIO 2 | RATIO 3 | RATIO 4 | RATIO 5 | RATIO 6 | RATIO 7 |
| | | | | .05 | .10 | .15 | .20 | .25 | .50 | 1.00 |
| HYDROGRAPH AT | 1 | .76 | 1 | 150. | 303. | 448. | 599. | 749. | 1498. | 2996. |
| | (1.97) | (| (| 4.24)(| 8.48)(| 12.72)(| 16.96)(| 21.21)(| 42.41)(| 84.82)(|
| ADJUSTED TO | 2 | .76 | 1 | 158. | 293. | 446. | 597. | 748. | 1498. | 2995. |
| | (1.97) | (| (| 3.97)(| 8.51)(| 12.62)(| 16.92)(| 21.18)(| 42.42)(| 84.81)(|

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 INITIAL VALUE SPILLWAY CREST TOP OF DAM
 775.03 775.00 779.50
 STORAGE 0. 30.
 OUTFLOW 0. 377.

| RATIO
OF
PNE | MAXIMUM
RESERVOIR
W.S. ELEV | MAXIMUM
DEPTH
OVER DAM | MAXIMUM
STORAGE
AC-FT | MAXIMUM
OUTFLOW
CFS | DURATION
OVER TOP
HOURS | TIME OF | |
|--------------------|-----------------------------------|------------------------------|-----------------------------|---------------------------|-------------------------------|----------------------|------------------|
| | | | | | | MAX OUTFLOW
HOURS | FAILURE
HOURS |
| .05 | 778.62 | 0.00 | 24. | 108. | 0.00 | 42.25 | 0.00 |
| .10 | 779.31 | 0.00 | 29. | 293. | 0.00 | 41.25 | 0.00 |
| .15 | 779.64 | .14 | 31. | 486. | 1.50 | 41.25 | 0.00 |
| .20 | 779.88 | .38 | 33. | 597. | 2.75 | 41.25 | 0.00 |
| .25 | 780.08 | .58 | 34. | 748. | 3.50 | 41.25 | 0.00 |
| .50 | 780.73 | 1.23 | 40. | 1498. | 6.25 | 41.25 | 0.00 |
| 1.00 | 781.54 | 2.04 | 47. | 2995. | 8.75 | 41.25 | 0.00 |

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DAT