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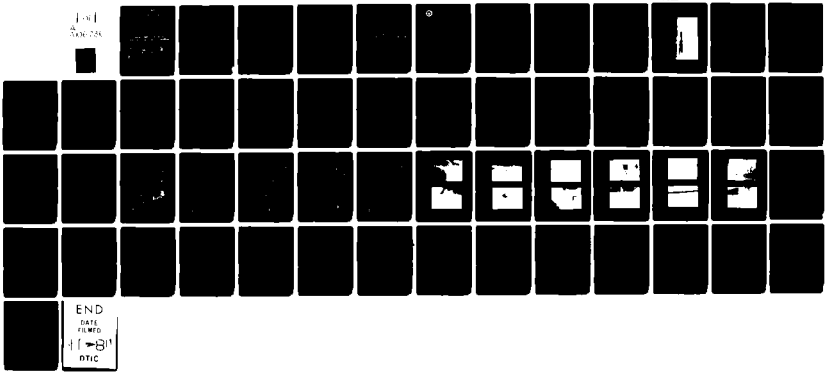

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MISSOURI-KANSAS CITY BASIN

AD A106736

SKY HAVEN LAKE DAM

JOHNSON COUNTY, MISSOURI

MO 20177

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

JUNE 1980

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National Dam Safety Program
Skyhaven Lake Dam (MO 20177)
Johnson County, Missouri

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Black & Veatch, Consulting Engineer
(10) Paul R. /Zaman Edwin R. /Burton
Harry L. /Callahan

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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MISSOURI-KANSAS CITY BASIN

SKY HAVEN LAKE DAM

JOHNSON COUNTY, MISSOURI

MO 20177

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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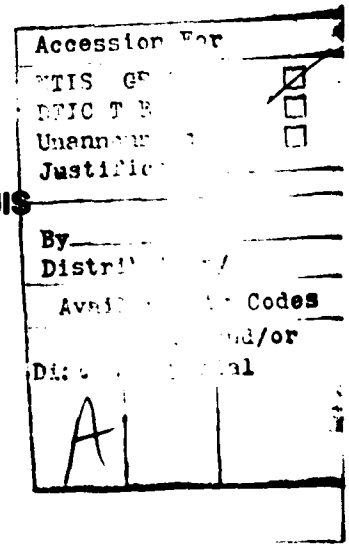


PREPARED BY: U.S. ARMY ENGINEER DISTRICT. ST. LOUIS

FOR: STATE OF MISSOURI

JUNE 1980

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

REPLY TO ATTENTION OF

LMSED-PD

SUBJECT: Sky Haven Lake Dam, Mo. ID No. 20177

Phase I Inspection Report

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

SUBMITTED BY: _____ _____
Chief, Engineering Division Date

APPROVED BY: _____ _____
Colonel, CE, District Engineer Date

SKY HAVEN LAKE DAM

JOHNSON COUNTY, MISSOURI

MISSOURI INVENTORY NO. 20177

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

JUNE 1980

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Sky Haven Lake Dam
State Located	Missouri
County Located	Johnson County
Stream	Tributary to Devil's Branch of Post Oak Creek
Date of Inspection	5 June 1980

Sky Haven 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 one mile downstream of the dam. Within the estimated damage zone are U.S. highway 50 and approximately eight trailers.

Our inspection and evaluation indicates the spillway does meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will not pass the probable maximum flood without overtopping but will pass 60 percent of the probable maximum flood and the one percent probability flood. The spillway design flood recommended by the guidelines is 50 to 100 percent of the probable maximum flood. Considering the volume of water impounded behind 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 seepage at the downstream toe of the dam along the right section of the embankment, erosion and sloughing on the upstream slope, settlement of

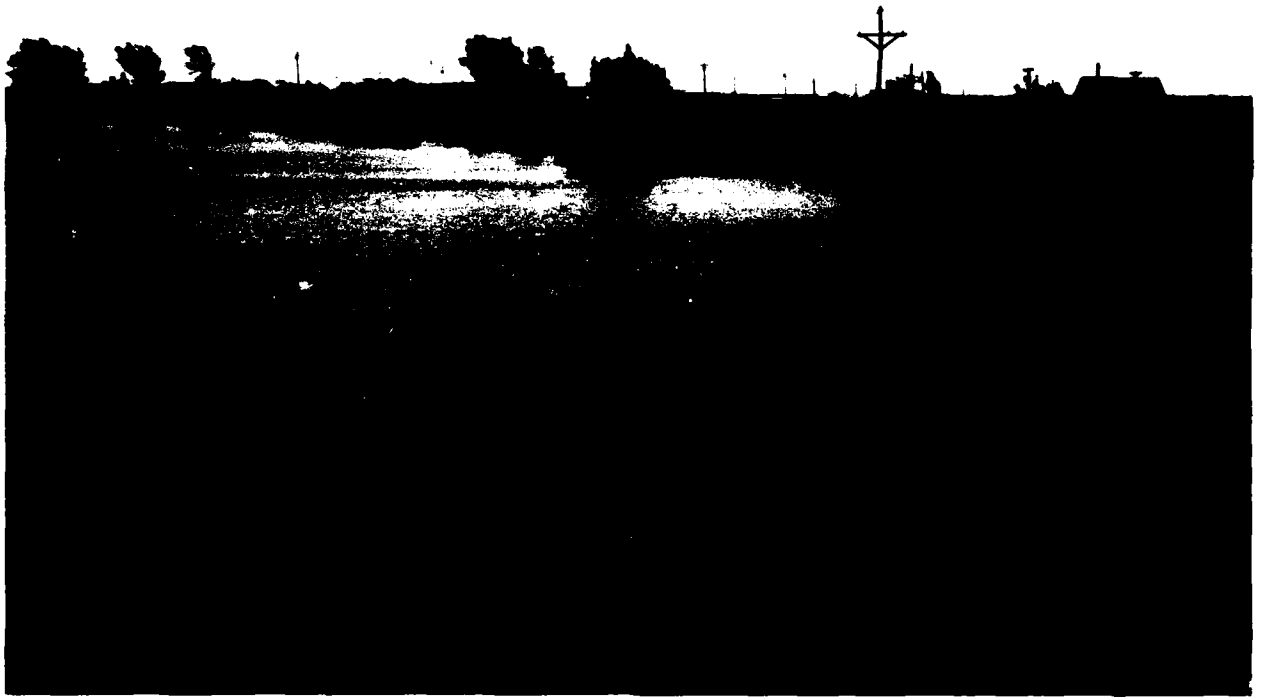
one section of the principal spillway pipe, and many small and medium sized trees growing on both the upstream and downstream faces of the dam. Seepage and stability analyses required by the guidelines were not available.

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

Paul R. Zaman
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
SKY HAVEN LAKE DAM

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

LIST OF PLATES

LIST OF PHOTOGRAPHS

APPENDIX

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 Sky Haven 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 adjacent to Sky Haven Airfield and U.S. Highway 50 in a valley of a tributary to Devil's Branch of Post Oak Creek (Plate 1). The watershed is a low hilly area consisting of a few residences with large grass yards and one runway of the airfield (Plate 2). The dam is approximately 1,075 feet long along the crest and 20 feet high. The dam crest is 18 feet wide, with gravel surface and serves as an access road to the houses around the lake. The downstream face of the dam slopes from the crest to the north ditch of westbound U.S. Highway 50.

(2) The principal spillway from the lake is an uncontrolled 42-inch reinforced concrete pipe without headwalls installed in the embankment. Flow through the pipe discharges into the U.S. Highway 50 drainage ditch. The emergency spillway consists of a low section cut in the natural overburden and embankment. Discharge through the emergency spillway overflows the embankment downstream to the U.S. Highway 50 drainage ditch.

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

b. Location. The dam is located in central Johnson 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 Warrensburg West, Missouri in Section 17 of T46N, R26W.

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 Sky Haven 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 Sky Haven Lake Dam the estimated flood damage zone extends approximately one mile downstream of the dam. Within the estimated damage zone are the four lane Highway U.S. 50 and about eight trailers.

e. Ownership. The dam is owned by Mr. Eugene V. Fryhoff, 12 N. Buena Vista, Englewood, Florida 33533 Telephone 813/474-8769.

f. Purpose of Dam. The dam forms a 12-acre lake used for recreation and water supply.

g. Design and Construction History. Data relating to the design and construction were not available. The dam was constructed during 1954 and 1955. The principal spillway was relocated by the Missouri Department of Highways when U.S. 50 was increased to a four-lane limited access highway.

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

1.3 PERTINENT DATA

a. Drainage Area - 62 acres

b. Discharge at Damsite.

(1) Normal discharge at the damsite is through an uncontrolled 42-inch concrete outlet pipe.

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

(3) Estimated ungated spillway capacity at maximum pool elevation 65 cfs (50 Percent Probable Maximum Flood Pool El. 783.6).

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

(1) Top of dam - 782.8 (see Plate 3)

(2) Emergency spillway crest - 782.2

(3) Principal spillway pipe inlet invert - 779.0

(4) Principal spillway pipe outlet invert - 778.1

(5) Maximum tailwater - Unknown.

d. Reservoir.

(1) Length of maximum pool - 1,500 feet ± (50 percent Probable maximum flood pool level)

(2) Length of normal pool - 1,100 feet ± (Principal spillway pipe invert)

e. Storage (Acre-feet).

(1) Top of dam - 109

(2) Emergency spillway crest - 98.4

(3) Principal spillway pipe invert - 47

(4) Design surcharge - Not available.

f. Reservoir Surface (Acres).

(1) Top of dam - 22.7

(2) Emergency spillway crest - 20.9

(3) Principal spillway pipe invert - 11.7

g. Dam.

(1) Type - Earth embankment

(2) Length - 1,075 feet

(3) Height - 20 feet ±

(4) Top width - 18 feet

(5) Side slopes - upstream face 1.0 V on 2.9 H, downstream face between 1.0 V on 1.7 H and 1.0 V on 3.6 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. Principal Spillway.

(1) Type - 42-inch concrete pipe.

(2) Inlet invert elevation - 779.0 feet m.s.l.

(3) Outlet invert elevation 778.1 feet m.s.l.

(4) Gates - None.

(5) Upstream channel - Not applicable.

(6) Downstream channel - North ditch of westbound U.S. Highway 50.

j. Emergency Spillway.

(1) Type - Grass open channel.

(2) Width of channel - 60 feet.

(3) Emergency spillway crest - 782.2

(4) Gates - None.

(5) Upstream channel - Not applicable.

(6) Downstream channel - Open channel along toe of the dam to north ditch of westbound U.S. Highway 50.

k. Regulating Outlets - None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Design data was unavailable.

2.2 CONSTRUCTION

Construction records were unavailable, however; according to the owner, the dam was constructed during 1954 and 1955 with assistance of the Department of Agriculture Soil Conservation Service.

2.3 OPERATION

Presently, water is pumped from the lake to supply the several houses located around the lake. Supply connections to these homes have been made to begin service from a rural water district in the very near future. The lake supply system will then be put on stand-by sevice. Documentation of past floods was not available.

2.4 GEOLOGY

The site of the dam and reservoir is located in a very broad and shallow valley. The dam impounds a very small intermittent, headwater tributary of Devil's Branch of Post Oak Creek.

The soils in the area of the dam and reservoir consist of the Deepwater, Macksburg and Snead soil series. The Deepwater series consists of deep, moderately well-drained soils formed in residuum weathered from shales on uplands. Bedrock depth is normally greater than five feet. The soils are classified for engineering purposes as low plastic silt (ML) and low-plastic clay (CL). The Macksburg soils consist of deep somewhat poorly-drained, soils formed in loess overlying limestone, shale, or sandstone bedrock. Bedrock depth is normally greater than five feet. The soils are classified for engineering purposes as low-plastic silt (ML) and low plastic clay (CL). The Snead series consists of moderately deep, moderately well-drained soils formed in residuum from thin shale layers underlain by limestone or sandstone. The soils are classified for engineering purposes as low-plastic clay (CL) and low-plastic silty clay to clayey silt (ML-CL).

The bedrock in the area of the dam and reservoir consists of interbedded limestone, shale, sandstone and coal of the Marmaton Group of the lower Pennsylvanian system.

2.5 EVALUATION

a. Availability. No engineering data could be obtained.

b. Adequacy. No engineering data were available upon which to make a detailed assessment of the design, construction, and operation. 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 Sky Haven Lake Dam was made on 5 June 1980. The inspection team consisted of Ed Burton, team leader; Paul Zaman, geotechnical engineer; Andy Dywan, civil engineer; Ray Herzog, geologist; Mark Snyder, hydrologist; and Alan Reif, structural engineer. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following conditions at the dam. No cracks were observed in the embankment. The upstream slope has irregularities in the waterline due to wave action, erosion, undercutting, and some evidence of minor sloughing. No instruments to measure the performance of the dam were located.

Clear seepage was observed at the downstream toe on the right portion of the dam. This seepage extends across an area, parallel to the dam centerline of about 100 feet. No visible flow was evident but the area was saturated. No toe drains or relief wells were observed.

The dam crest has a two-lane gravel roadway which provides access to several residences. The upstream slope of the embankment is faced with some riprap at and below the present waterline. The upstream slope also has many small trees, willows and an occasonal cottonwood, brush, and some grass. One cottonwood is 18 inches in diameter. The downstream slope is covered with grass, brush and occasional small trees, the largest about 8 inches in diameter. Some erosion was evident on the upstream slope due to wave action. A vertical step and undercutting from one to two feet were noted in several places. Erosion of the silty clay material was beginning at the top left side of the principal spillway inlet due to runoff from the roadway. No evidence was found to indicate that the embankment had ever been overtopped.

Evidence of maintenance included mowing of grass around the abutments. The roadway gravel surface was well maintained. The power company has cut some brush and small trees beneath the power line located parallel to and on the downstream slope (about 5 feet above the toe). Some riprap had been placed in isolated areas for erosion control. In general, the upstream and downstream slopes were covered with much brush, small trees and is considered to be poorly maintained. No animal burrows were observed.

c. Appurtenant Structures. The inspection team observed the following items pertaining to the appurtenant structures. The principal

spillway is a 42-inch reinforced concrete pipe without headwalls which runs through the embankment to provide uncontrolled discharge. The first 10-foot section of the RCP had settled at the inlet end causing a small separation at the crown of the first joint. Otherwise, alinement of the pipe was fairly good. No evidence of leaking joints was observed. The inlet to the 42-inch RCP was obstructed by a make-shift trash screen stretched across steel stakes and a 2-1/2 inch tree growing about two feet in front of the inlet. The outlet of the RCP spillway were clear of obstructions. About 5 feet of each end of the concrete pipe was inspected. The spillway pipe was found to be in good workable condition.

The emergency spillway consists of a low area at the right end of the dam. This low area is either grass lined or has the roadway gravel surfacing.

The emergency spillway contains no obstructions to flow and is considered to be in satisfactory condition. There was no evidence of erosion upstream or downstream of the spillway. It should be noted that an abnormally large spillway discharge would probably overflow and erode the embankment.

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

d. Geology. The soil in the area of the dam and reservoir consisted of sandy clay soil (CL) and localized layers of weathered sandstone. The bedrock consists of sandstone and shale. Sandstone was encountered in a shallow auger boring at the toe of the embankment near the right abutment.

Samples of the embankment materials were taken near the center of the downstream face using an Oakfield sampler. The materials were visually classified as low-plastic silty clay (CL). Based on these samples and visual observations, the embankment is anticipated to consist of low-plastic silty clay (CL).

The abutments of the dam consist of interbedded sandstone and shale of the Marmaton Group. The foundation of the dam is anticipated to be residual silty clay overlying sandstone or shale bedrock.

e. Reservoir Area. No slumping or slides of the reservoir banks were observed. The area considered as the upstream channel to the lake contains no defined channel but a very small area of residential grass yards and one runway of the Sky Haven Airfield. The residential grass yards were well maintained and should drain well. The lake contains a minor amount of siltation.

f. Downstream Channel. The channel downstream of the spillways is the north ditch of the west bound U.S. Highway 50. A 42-inch culvert passes under the highway about 250 feet west of the principal spillway pipe outlet. The ditch continues to the west to another culvert approximately 1200 feet west of the principal spillway pipe outlet which is located at the low point of the ditch where the highway crosses a natural stream. There are no obstructions to flow in the highway ditch. The highway constitutes a major obstruction.

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 poor quality of riprap on the face of the dam has resulted in wave action erosion of the embankment. If not corrected, wave action will continue to erode the embankment and could lead to slope stability problems. The separated joint of the principal spillway pipe can result in leakage from the pipe during high flows which in turn can lead to erosion of material from around the pipe resulting in displacement of the pipe and/or failure of the embankment. The growth of small trees and brush and the uncut grass is not presently a serious problem, but if allowed to go unchecked, it 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 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, pumped withdrawals for water supply to several residences, evaporation, transpiration, and capacity of the uncontrolled spillways.

4.2 MAINTENANCE OF DAM

There is no regular systematic maintenance program, but the Homes Association looks after the water supply facilities and the access road on the crest. Also, the Missouri Department of Highways and the power company have done some cutting of brush and small trees on the downstream slope along the toe of the embankment where the powerline runs parallel to the dam for several hundred feet.

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 systematic maintenance program should be started to include mowing the grass cover on the embankment in order to discourage animal burrowing. The brush and trees on the embankment should be removed more frequently. The areas of seepage should be monitored periodically and, if flows increase significantly or if seepage flows become muddy, a qualified engineer should be consulted.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data pertaining to hydrology and hydraulics were unavailable.

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

c. Visual Observations.

(1) The principal spillway appears to be in good condition. The lake level at the time of the inspection was at the inlet level and there was no flow through the pipe. About five feet of the inlet and outlet ends were exposed and in good condition. There was no headwall at either end. The first 10-foot section of the pipe had settled at the inlet end causing a small separation at the crown of the first joint. Otherwise, the alinement of the pipe was fairly good and there was no evidence of leaky joints. The spillway pipe discharges into the north ditch of westbound U.S. Highway 50. Discharges can flow west along the ditch of U.S. Highway 50 or pass under U.S. Highway 50 through a 42-inch diameter concrete culvert.

(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 60 percent of the probable maximum flood without overtopping the dam. The spillways will also pass the one percent probability flood estimated to have a peak outflow of 11 cfs developed by a 24-hour, one percent probability 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 volume of water impounded by 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 the probable maximum flood overtopping the dam would be 480 cfs of the total discharge from the reservoir of 800 cfs. The estimated duration of overtopping is 3.3 hours with a maximum height of 0.8 feet. The embankment could be jeopardized by overtopping for this period of time.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately one mile downstream of the dam. Within the estimated damage zone are U.S. Highway 50 and approximately eight trailers.

There does not appear to be any flood plain regulations or other constraints in force to limit future downstream development.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

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

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

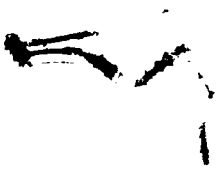
c. Operating Records. No operational records exist.

d. Postconstruction Changes. The principal spillway was relocated by the Missouri Department of Highways when U.S. 50 was increased to a four-lane limited access highway.

e. Seismic Stability. The dam is located in Seismic Zone 1 which is considered 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, conditons, and strengths; embankment zoning; and embankment geomtry.

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 and sloughing of the upstream face of the embankment at normal lake level due to undercutting of the slope by wave action, settlement of one section of the principal spillway pipe, seepage from the right section of the dam, and the growth of brush and trees on the embankment.

b. Adequacy of Information. Due to the inadequacy 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. It is the opinion of the inspection team that a program should be developed as soon as possible to implement remedial measures recommended in paragraph 7.2b. If the safety deficiencies listed in paragraph 7.1a are not corrected, they will continue to deteriorate and lead to a serious potential of failure.

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 2.5.b 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 was 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. No alternative measures other than those noted in paragraph 7.2.b. below are recommended.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures should be carried out under the direction of an engineer experienced in the design, construction, and inspection of dams:

(1) Erosion damage to the upstream face of the dam should be repaired and 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 separated joint of the first section of the principal spillway pipe should be repaired to prevent leakage from the joint during high flows.

(3) The seepage areas noted during the visual inspection should be closely monitored and documented as to quantity and quality of flow. If flow increases significantly or if seepage flow becomes muddy, a qualified engineer should be consulted.

(4) 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.

(5) Seepage and stability analysis should be performed.

(6) 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 seeps and lake. More frequent inspections may be required if additional deficiencies are observed or the severity of the reported deficiencies increase.

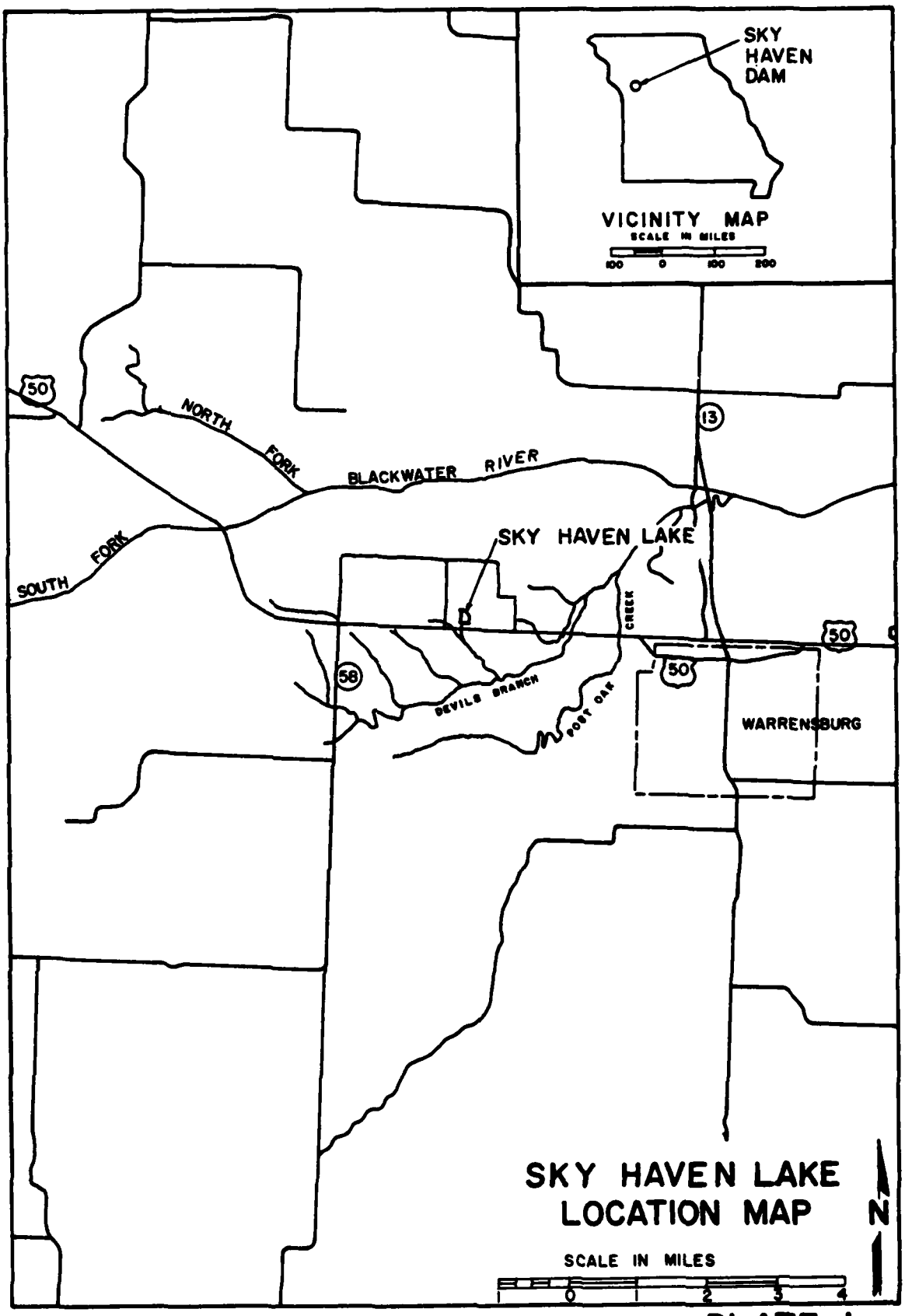

SKY
HAVEN
DAM
VICINITY MAP
SCALE IN MILES
100 0 100 200
50
NORTH
FORK
BLACKWATER RIVER
13
SOUTH FORK
SKY HAVEN LAKE
CREEK
50
58
50
DEVILS BRANCH
POST OAK
WARRENSBURG
SKY HAVEN LAKE
LOCATION MAP
N
SCALE IN MILES
0 1 2 3 4

PLATE 1

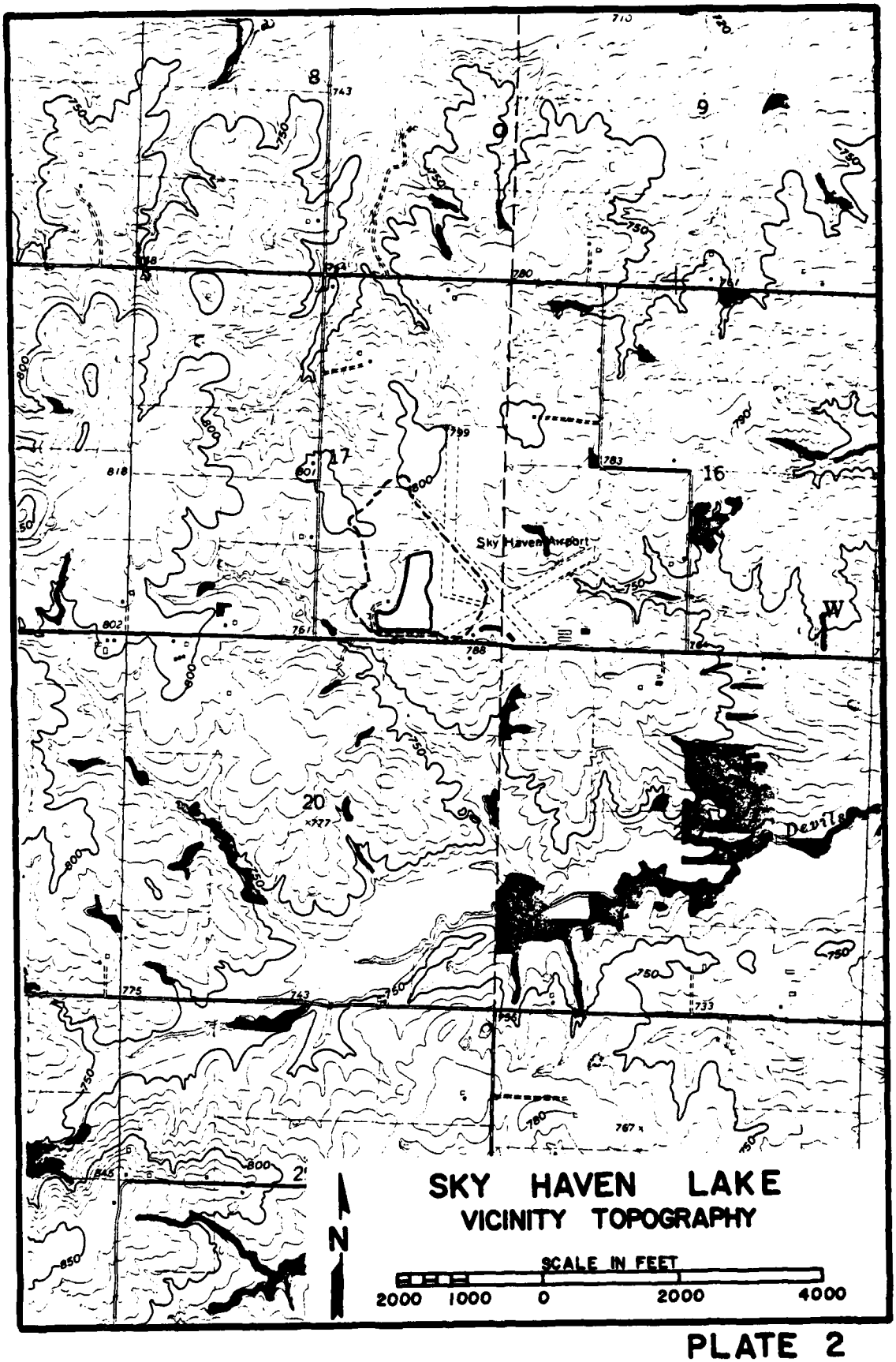

8
9
17
16
20
Sky Haven Airport
Devils
N
SKY HAVEN LAKE
VICINITY TOPOGRAPHY
SCALE IN FEET
2000 1000 0 2000 4000

PLATE 2

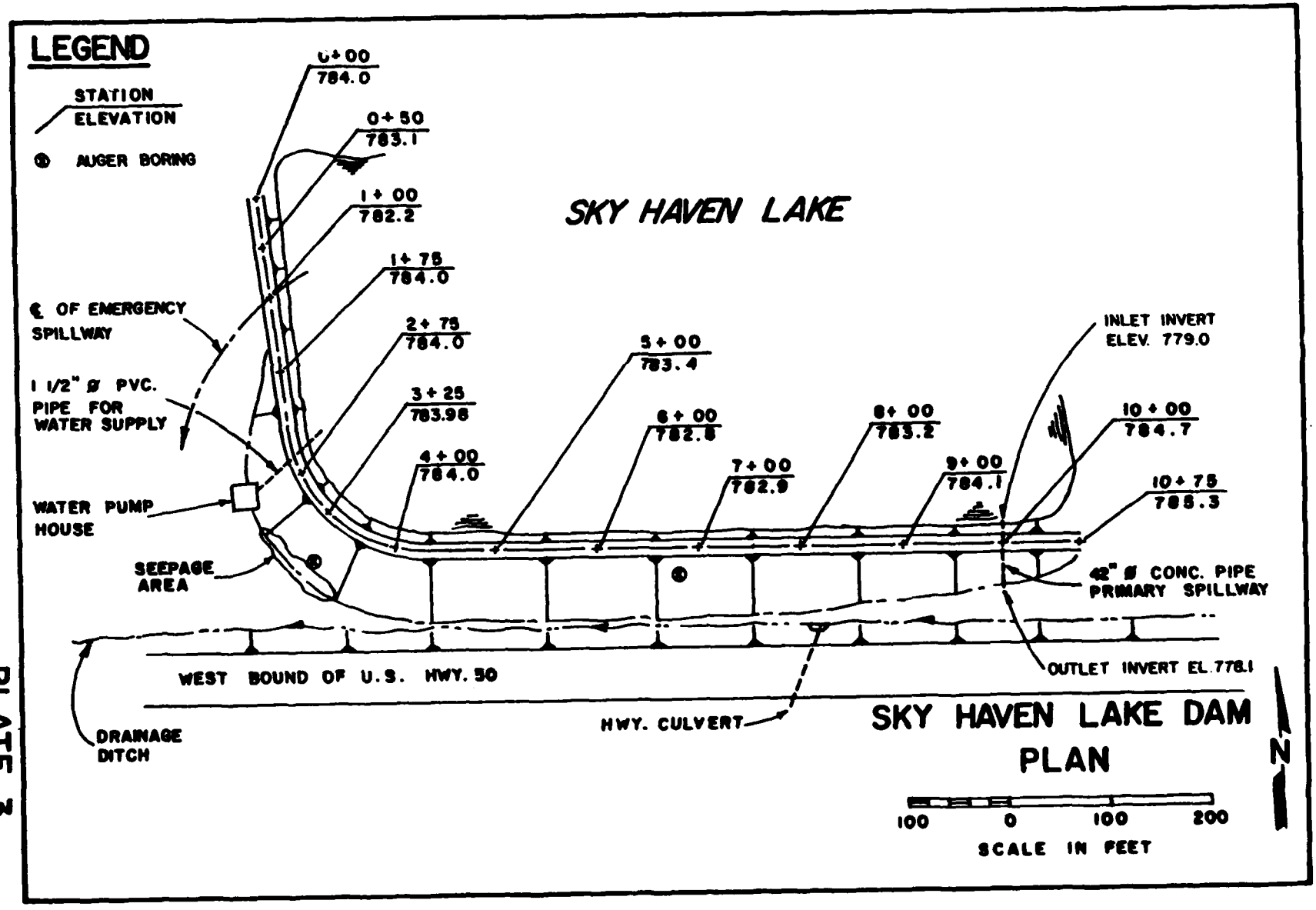

LEGEND
STATION
ELEVATION
AUGER BORING
SKY HAVEN LAKE
0+00
784.0
0+50
783.1
1+00
782.2
1+75
784.0
2+75
784.0
3+25
783.98
4+00
784.0
5+00
783.4
6+00
782.8
7+00
782.9
8+00
783.2
9+00
784.1
10+00
784.7
10+75
785.3
℄ OF EMERGENCY SPILLWAY
1 1/2" ø PVC. PIPE FOR WATER SUPPLY
WATER PUMP HOUSE
SEEPAGE AREA
INLET INVERT ELEV. 779.0
42" ø CONC. PIPE PRIMARY SPILLWAY
OUTLET INVERT EL. 778.1
WEST BOUND OF U.S. HWY. 50
HWY. CULVERT
DRAINAGE DITCH
SKY HAVEN LAKE DAM
PLAN
N
100 0 100 200
SCALE IN FEET

PLATE 3

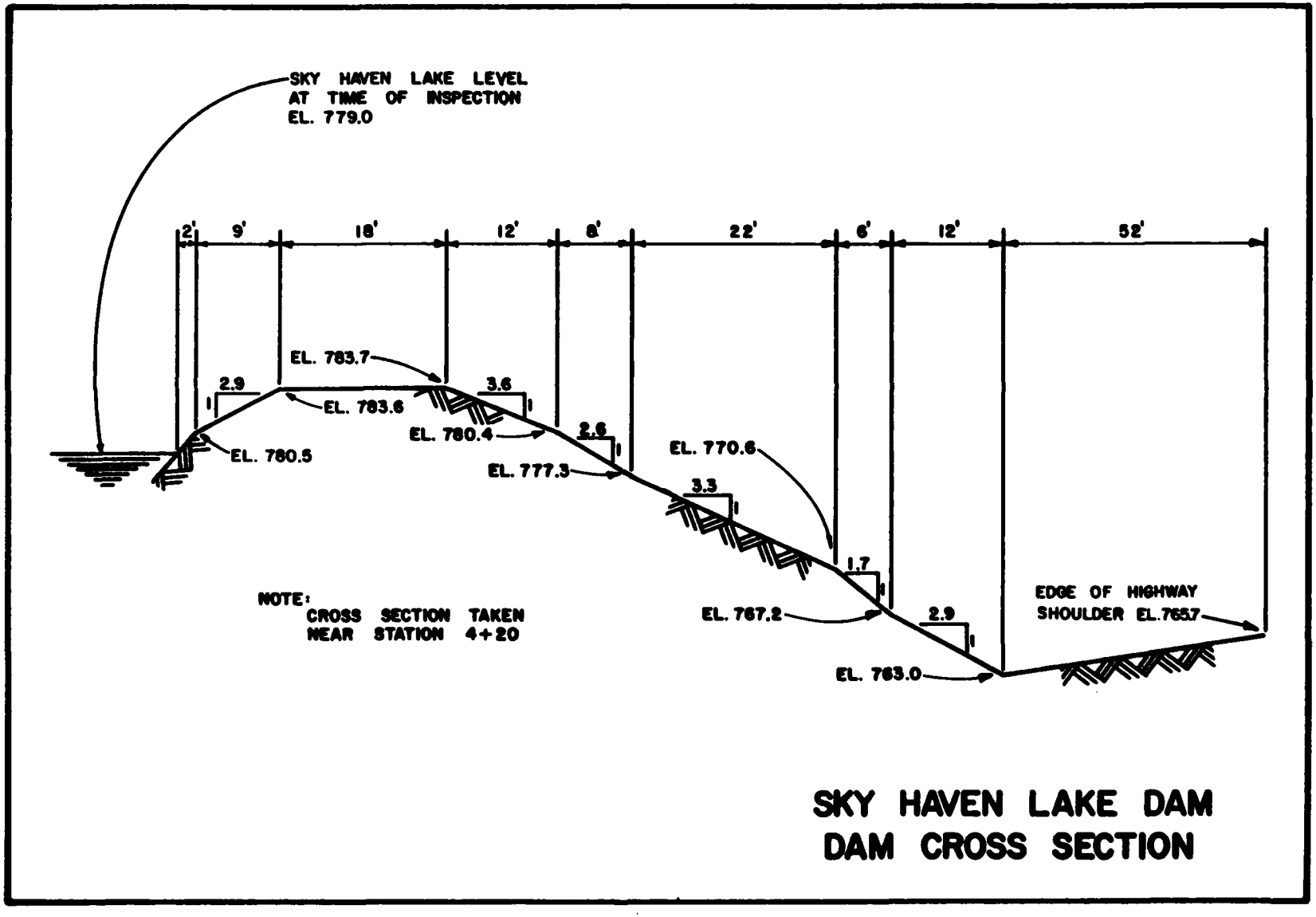
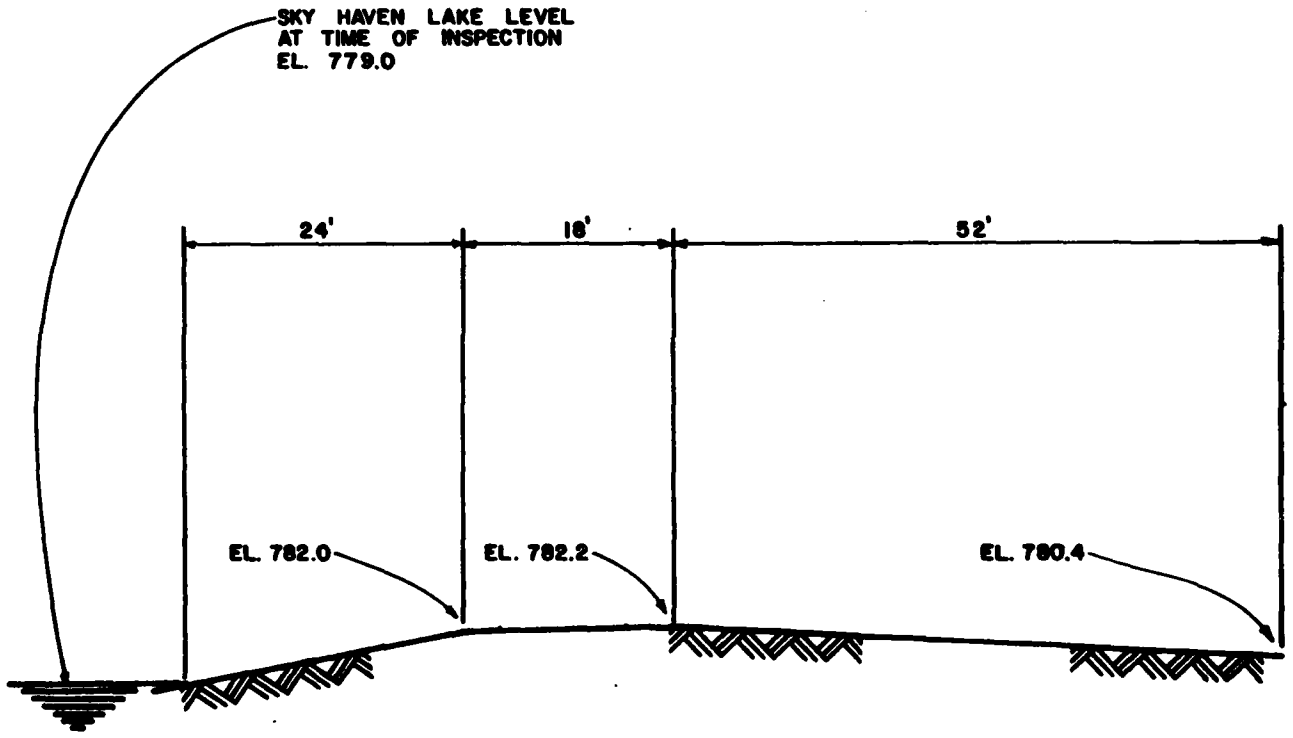


PLATE 4

SKY HAVEN LAKE DAM
DAM CROSS SECTION



SKY HAVEN LAKE DAM
EMERGENCY SPILLWAY PROFILE

PLATE 5

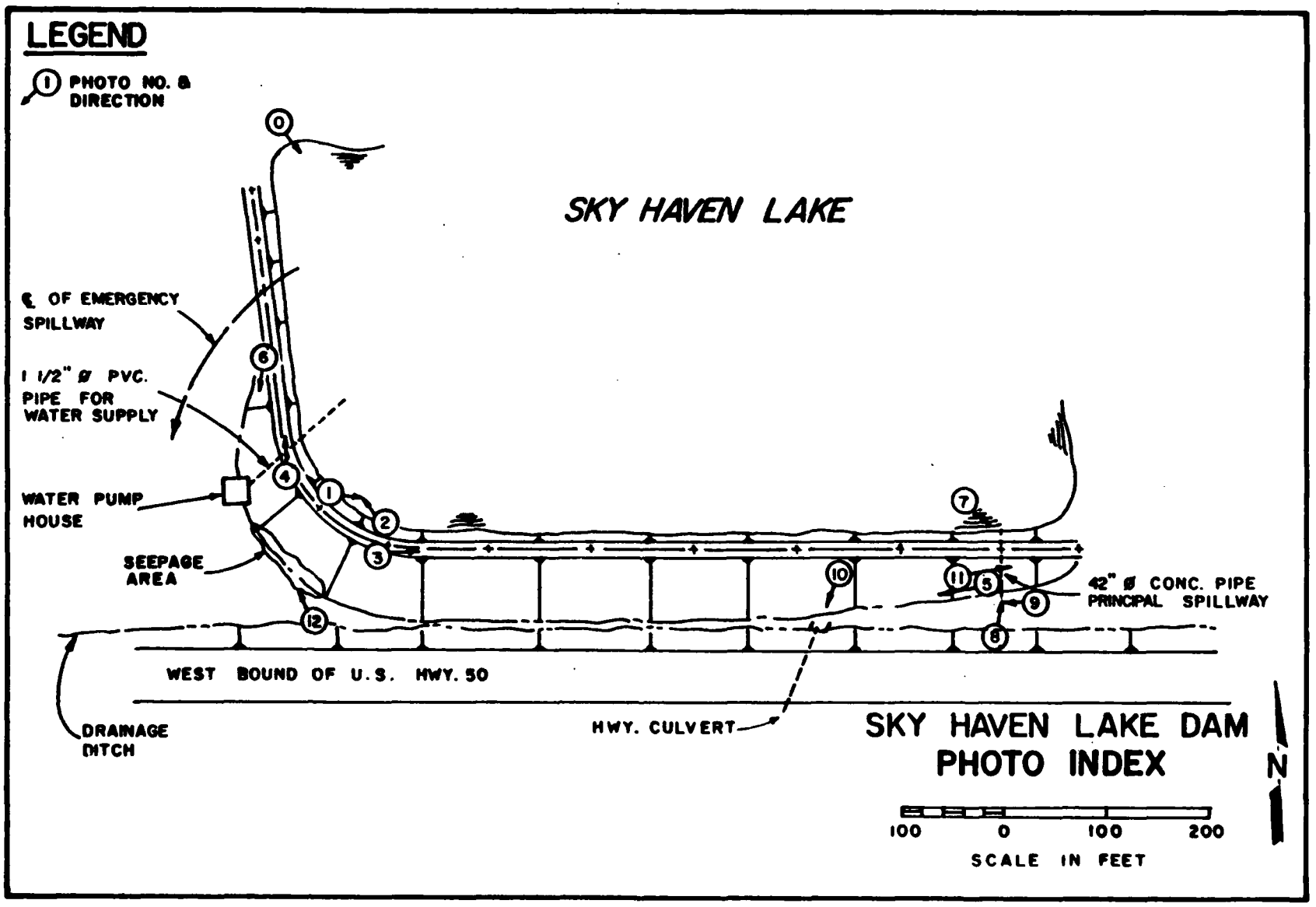

LEGEND
PHOTO NO. & DIRECTION
SKY HAVEN LAKE
℄ OF EMERGENCY SPILLWAY
1 1/2" ø PVC. PIPE FOR WATER SUPPLY
WATER PUMP HOUSE
SEEPAGE AREA
42" ø CONC. PIPE PRINCIPAL SPILLWAY
WEST BOUND OF U.S. HWY. 50
DRAINAGE DITCH
HWY. CULVERT
SKY HAVEN LAKE DAM
PHOTO INDEX
N
100 0 100 200
SCALE IN FEET

PLATE 6

PHOTO 1: UPSTREAM FACE OF DAM

PHOTO 2: UPSTREAM FACE AT RIGHT END OF DAM

PHOTO 3: CREST OF DAM

PHOTO 4: CREST AT RIGHT END OF DAM

PHOTO 5: DOWNSTREAM SLOPE OF DAM

PHOTO 6: DOWNSTREAM SLOPE AT RIGHT END OF DAM

PHOTO 7: PRINCIPAL SPILLWAY INLET

PHOTO 8: PRINCIPAL SPILLWAY OUTLET

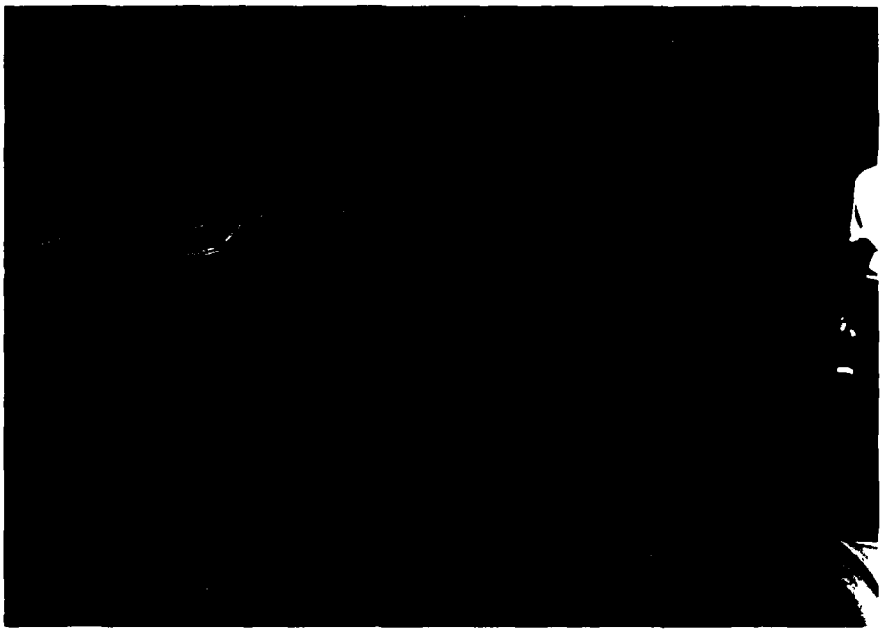


PHOTO 9: HIGHWAY DITCH BELOW SPILLWAY OUTLET

PHOTO 10: HIGHWAY CULVERT DOWNSTREAM OF DAM

PHOTO 11: EMBANKMENT EROSION UPSTREAM SIDE OF DAM

PHOTO 12: SEEPAGE AREA AT DOWNSTREAM TOE OF DAM

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 spillways. 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 24-hour PMP storm was determined according to the procedures outlined in HMR-33 and EM 1110-2-1411. The Sweet Springs, Missouri rainfall distribution (5 min. interval - 24 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 spillways.

The synthetic unit hydrograph for the watershed was developed by the computer program using the Soil Converation 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 principal spillway at elevation 779.0 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 (2). 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 principal spillway was determined from nomographs for pipe culverts with inlet and outlet control (3). It was assumed that the trash screen is kept free of debris.

The result of the routing analyses indicates that 60 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)	62 acres
Hydraulic Length of Watercourse (L)	1,000 feet
Elevation Differences in Watershed (H)	23 feet
Wave Velocity (V)	19.3 feet per second
Length of Reservoir (L_w)	1,150 feet
Lag Time (L_g)	4.7 minutes (AMC II and AMC III)
Time of concentration (T_c)	7.8 minutes 2.48 hours (AMC II and AMC III)
Duration (D)	1 min. (AMC II and AMC III) (use 5 minutes in each case)

Time (Min.) *	Discharge (cfs) *
0	311
5	301
10	95
15	30
20	10
25	3
30	0

* From HEC-1 computer output

FORMULAS USED:

$$T_c = (11.9 \times L^3/H)^{0.385} + V/Lw \quad (4 \text{ and } 5)$$

$$L_g = 0.6\ T_c$$

$$D = 0.133\ T_c$$

TABLE 2

RAINFALL-RUNOFF VALUES

Selected Storm Event	Storm Duration (Hours)	Rainfall (Inches)	Runoff (Inches)	Loss (Inches)
PMP	24	32.17	30.45	1.72
1% Probability	24	7.49	4.36	3.13

Additional Data:

1) The soil associations in this watershed are Deepwater and Macksburg (6).
   60 percent of drainage area in hydrologic soil group B.
   40 percent of drainage area in hydrologic soil group C.
   100 percent of the land use was grassland.
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 (5).

TABLE 3

ELEVATION, SURFACE AREA, STORAGE, AND DISCHARGE RELATIONSHIPS

Elevation (feet-MSL)	Lake Surface Area (acres)	Lake Storage (acre-ft)	Spillway Discharge (cfs)
*779.0	11.7	47	0
**782.2	20.9	98	45
***782.8	22.7	109	94

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

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

TABLE 4

SPILLWAY RATING CURVE

Reservoir Elevation (ft-msl)	Principal Spillway Discharge (cfs)	Emergency Spillway Discharge (cfs)	Total Spillway Discharges (cfs)
779.0	0	0	0
781.0	21	0	21
782.0	38	0	38
*782.2	45	0	45
782.5	55	5	60
**782.8	62	32	94

*Emergency Spillway Crest Elevation
**Top of Dam Elevation

METHOD USED:

Principal spillway release rates were determined by nomographs for pipe culverts with inlet and outlet control (3).

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:

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

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

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

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)
Y = change in elevation across the section (feet)
A = flow area (sq. ft.)
T = top width (feet)
Q = flow (cfs)
g = 32.2 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	*779.0	47	0	-
0.50	696	782.6	104	65	0
0.60	835	782.8	109	94	0
1.00	1,392	783.6	127	805	0.8

* Principal spillway pipe invert elevation

BIBLIOGRAPHY

(1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Davis, California.

(2) U.S. Army Corps of Engineers, St. Louis District, Hydrologic/ Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams, 12 December 1979.

(3) U.S. Department of Commerce, Bureau of Public Roads, Hydraulic Engineering Circular No. 5, Hydraulic Charts for the Selection of Highway Culverts, December, 1965.

(4) U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1974, Washington, D.C.

(5) U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, August 1972.

(6) U.S. Department of Agriculture, Soil Conservation Service, Soils Report for Johnson County, Missouri.

(7) U.S. Department of Agriculture, Soil Conservation Service, Soil Survey Interpretations and Field Maps, 1980.

(8) Mary H. McCracken, Missouri Division of Geological Survey, Geologic Map of Missouri, 1961.

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FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION    JULY 1978
  LAST MODIFICATION  06 FEB 80
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    1  A1MISSOURI DAM INSPECTION PROGRAM
    2  A2ST. LOUIS DISTRICT US ARMY CORPS OF ENGINEERS
    3  A3SKY HAVEN LAKE DAM
    4  B    288       0       5       0       0       0       0       0       0       0
    5  B1     5
    6  J      1       6       1
    7  J1    .5      .55      .6      .65      .7     1.0
    8  K      0       1                                3       1
    9  K1   SKY HAVEN LAKE (24 HR. PROBABLE MAXIMUM RUNOFF)
   10  M      1       2    .097                        1
   11  P            24.75     101     120     130
   12  T                                                    -1      -87
   13  W2           .078
   14  X                      1
   15  K      1       2                                    1
   16  K1   ROUTE THROUGH SPILLWAY
   17  Y                              1       1
   18  Y1     1                                        -779.0      -1
   19  Y4 779.0  780.75   781.0   781.5   782.0   782.5   783.0   783.5   784.0   784.5
   20  Y4 785.0  785.5
   21  Y5     0.     17.     21.     31.     38.     55.     67.     77.     86.     91.
   22  Y5   100.    106.
   23  SA0.0   11.7    14.4    44.1
   24  SE767.0 779.0   780.0   790.0
   25  SS779.0
   26  SD782.8
   27  SL0.     60.    185.    315.    365.    437.    662.    905.   1037.   1145.
   28  SV782.2 782.8   782.9   783.1   783.2   783.4   784.0   784.1   784.7   785.3
   29  K     99
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FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 06 FEB 80

MISSOURI DAM INSPECTION PROGRAM
ST. LOUIS DISTRICT US ARMY CORPS OF ENGINEERS
SKY HAVEN LAKE DAM

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	5	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 6 LRTIO= 1
RTIOS= .50 .55 .60 .65 .70 1.00

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

SUB-AREA RUNOFF COMPUTATION

SKY HAVEN LAKE (24 HR. PROBABLE MAXIMUM RUNOFF)

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	3	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.10	.00	.10	1.00	.000	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
.00	24.75	101.00	120.00	130.00	.00	.00	.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	.00	.00	1.00	.00	.00	1.00	-1.00	-87.00	.00	.00

CURVE NO = -87.00 WETNESS = -1.00 EFFECT CN = 87.00

UNIT HYDROGRAPH DATA
TC= .00 LAG= .08

RECESSION DATA
STRTQ= .00 QRCSN= .00 RTIOR= 1.00

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

UNIT HYDROGRAPH 7 END OF PERIOD ORDINATES, TC= .00 HOURS, LAG= .08 VOL= 1.00
311. 301. 95. 30. 10. 3. 0.

END-OF-PERIOD FLOW

HO.	DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	END-OF-PERIOD FLOW HO.	DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01		.05	1	.01	.00	.01	0.	1.01		12.05	145	.21	.20	.01	89.
1.01		.10	2	.01	.00	.01	0.	1.01		12.10	146	.21	.20	.01	130.
1.01		.15	3	.01	.00	.01	0.	1.01		12.15	147	.21	.20	.01	144.
1.01		.20	4	.01	.00	.01	0.	1.01		12.20	148	.21	.20	.01	148.
1.01		.25	5	.01	.00	.01	0.	1.01		12.25	149	.21	.20	.01	150.
1.01		.30	6	.01	.00	.01	0.	1.01		12.30	150	.21	.20	.01	151.
1.01		.35	7	.01	.00	.01	0.	1.01		12.35	151	.21	.20	.01	151.
1.01		.40	8	.01	.00	.01	0.	1.01		12.40	152	.21	.20	.01	151.
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1.01		.50	10	.01	.00	.01	0.	1.01		12.50	154	.21	.20	.01	152.
1.01		.55	11	.01	.00	.01	0.	1.01		12.55	155	.21	.20	.01	152.
1.01		1.00	12	.01	.00	.01	0.	1.01		13.00	156	.21	.20	.01	152.
1.01		1.05	13	.01	.00	.01	0.	1.01		13.05	157	.25	.24	.01	165.
1.01		1.10	14	.01	.00	.01	0.	1.01		13.10	158	.25	.24	.01	177.
1.01		1.15	15	.01	.00	.01	0.	1.01		13.15	159	.25	.24	.01	182.
1.01		1.20	16	.01	.00	.01	0.	1.01		13.20	160	.25	.24	.01	183.
1.01		1.25	17	.01	.00	.01	0.	1.01		13.25	161	.25	.24	.01	184.
1.01		1.30	18	.01	.00	.01	0.	1.01		13.30	162	.25	.25	.00	184.
1.01		1.35	19	.01	.00	.01	0.	1.01		13.35	163	.25	.25	.00	184.
1.01		1.40	20	.01	.00	.01	0.	1.01		13.40	164	.25	.25	.00	184.
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1.01		1.50	22	.01	.00	.01	0.	1.01		13.50	166	.25	.25	.00	185.
1.01		1.55	23	.01	.00	.01	0.	1.01		13.55	167	.25	.25	.00	185.
1.01		2.00	24	.01	.00	.01	0.	1.01		14.00	168	.25	.25	.00	185.
1.01		2.05	25	.01	.00	.01	0.	1.01		14.05	169	.31	.31	.00	204.
1.01		2.10	26	.01	.00	.01	1.	1.01		14.10	170	.31	.31	.00	223.
1.01		2.15	27	.01	.00	.01	1.	1.01		14.15	171	.31	.31	.00	229.
1.01		2.20	28	.01	.00	.01	1.	1.01		14.20	172	.31	.31	.00	231.
1.01		2.25	29	.01	.00	.01	1.	1.01		14.25	173	.31	.31	.00	231.
1.01		2.30	30	.01	.00	.01	1.	1.01		14.30	174	.31	.31	.00	232.
1.01		2.35	31	.01	.00	.01	1.	1.01		14.35	175	.31	.31	.00	232.
1.01		2.40	32	.01	.00	.01	2.	1.01		14.40	176	.31	.31	.00	232.
1.01		2.45	33	.01	.00	.01	2.	1.01		14.45	177	.31	.31	.00	232.
1.01		2.50	34	.01	.00	.01	2.	1.01		14.50	178	.31	.31	.00	232.
1.01		2.55	35	.01	.00	.01	2.	1.01		14.55	179	.31	.31	.00	232.
1.01		3.00	36	.01	.00	.01	2.	1.01		15.00	180	.31	.31	.00	232.
1.01		3.05	37	.01	.00	.01	2.	1.01		15.05	181	.19	.19	.00	195.
1.01		3.10	38	.01	.00	.01	2.	1.01		15.10	182	.38	.38	.00	217.
1.01		3.15	39	.01	.00	.01	2.	1.01		15.15	183	.38	.38	.00	262.
1.01		3.20	40	.01	.00	.01	3.	1.01		15.20	184	.57	.57	.00	335.
1.01		3.25	41	.01	.00	.01	3.	1.01		15.25	185	.66	.66	.00	426.
1.01		3.30	42	.01	.00	.01	3.	1.01		15.30	186	1.61	1.60	.01	768.
1.01		3.35	43	.01	.00	.01	3.	1.01		15.35	187	2.66	2.65	.01	1392.
1.01		3.40	44	.01	.00	.01	3.	1.01		15.40	188	1.04	1.04	.00	1299.
1.01		3.45	45	.01	.00	.01	3.	1.01		15.45	189	.66	.66	.00	827.
1.01		3.50	46	.01	.00	.01	3.	1.01		15.50	190	.57	.57	.00	573.
1.01		3.55	47	.01	.00	.01	3.	1.01		15.55	191	.38	.38	.00	415.
1.01		4.00	48	.01	.00	.01	3.	1.01		16.00	192	.38	.38	.00	326.
1.01		4.05	49	.01	.00	.01	4.	1.01		16.05	193	.29	.29	.00	269.
1.01		4.10	50	.01	.01	.01	4.	1.01		16.10	194	.29	.29	.00	234.
1.01		4.15	51	.01	.01	.01	4.	1.01		16.15	195	.29	.29	.00	223.
1.01		4.20	52	.01	.01	.01	4.	1.01		16.20	196	.29	.29	.00	220.
1.01		4.25	53	.01	.01	.01	4.	1.01		16.25	197	.29	.29	.00	219.

1.01		4.30	54	.01	.01	.01	4.	1.01		16.30	198	.29	.29	.00	218.

1.01	4.30	54	.01	.01	.01	4.	1.01	16.30	198	.29	.29	.00	218.
1.01	4.35	55	.01	.01	.01	4.	1.01	16.35	199	.29	.29	.00	218.
1.01	4.40	56	.01	.01	.01	4.	1.01	16.40	200	.29	.29	.00	218.
1.01	4.45	57	.01	.01	.01	4.	1.01	16.45	201	.29	.29	.00	218.
1.01	4.50	58	.01	.01	.01	4.	1.01	16.50	202	.29	.29	.00	218.
1.01	4.55	59	.01	.01	.01	4.	1.01	16.55	203	.29	.29	.00	218.
1.01	5.00	60	.01	.01	.01	5.	1.01	17.00	204	.29	.29	.00	218.
1.01	5.05	61	.01	.01	.01	5.	1.01	17.05	205	.23	.23	.00	199.
1.01	5.10	62	.01	.01	.01	5.	1.01	17.10	206	.23	.23	.00	180.
1.01	5.15	63	.01	.01	.01	5.	1.01	17.15	207	.23	.23	.00	174.
1.01	5.20	64	.01	.01	.01	5.	1.01	17.20	208	.23	.23	.00	172.
1.01	5.25	65	.01	.01	.01	5.	1.01	17.25	209	.23	.23	.00	172.
1.01	5.30	66	.01	.01	.01	5.	1.01	17.30	210	.23	.23	.00	172.
1.01	5.35	67	.01	.01	.01	5.	1.01	17.35	211	.23	.23	.00	172.
1.01	5.40	68	.01	.01	.01	5.	1.01	17.40	212	.23	.23	.00	172.
1.01	5.45	69	.01	.01	.01	5.	1.01	17.45	213	.23	.23	.00	172.
1.01	5.50	70	.01	.01	.01	5.	1.01	17.50	214	.23	.23	.00	172.
1.01	5.55	71	.01	.01	.01	5.	1.01	17.55	215	.23	.23	.00	172.
1.01	6.00	72	.01	.01	.01	5.	1.01	18.00	216	.23	.23	.00	172.
1.01	6.05	73	.07	.04	.03	14.	1.01	18.05	217	.02	.02	.00	107.
1.01	6.10	74	.07	.04	.03	23.	1.01	18.10	218	.02	.02	.00	44.
1.01	6.15	75	.07	.04	.03	27.	1.01	18.15	219	.02	.02	.00	25.
1.01	6.20	76	.07	.04	.03	29.	1.01	18.20	220	.02	.02	.00	18.
1.01	6.25	77	.07	.04	.02	30.	1.01	18.25	221	.02	.02	.00	16.
1.01	6.30	78	.07	.04	.02	31.	1.01	18.30	222	.02	.02	.00	16.
1.01	6.35	79	.07	.04	.02	32.	1.01	18.35	223	.02	.02	.00	15.
1.01	6.40	80	.07	.04	.02	33.	1.01	18.40	224	.02	.02	.00	15.
1.01	6.45	81	.07	.05	.02	34.	1.01	18.45	225	.02	.02	.00	15.
1.01	6.50	82	.07	.05	.02	35.	1.01	18.50	226	.02	.02	.00	15.
1.01	6.55	83	.07	.05	.02	35.	1.01	18.55	227	.02	.02	.00	15.
1.01	7.00	84	.07	.05	.02	36.	1.01	19.00	228	.02	.02	.00	15.
1.01	7.05	85	.07	.05	.02	36.	1.01	19.05	229	.02	.02	.00	15.
1.01	7.10	86	.07	.05	.02	37.	1.01	19.10	230	.02	.02	.00	15.
1.01	7.15	87	.07	.05	.01	37.	1.01	19.15	231	.02	.02	.00	15.
1.01	7.20	88	.07	.05	.01	38.	1.01	19.20	232	.02	.02	.00	15.
1.01	7.25	89	.07	.05	.01	39.	1.01	19.25	233	.02	.02	.00	15.
1.01	7.30	90	.07	.05	.01	39.	1.01	19.30	234	.02	.02	.00	15.
1.01	7.35	91	.07	.05	.01	39.	1.01	19.35	235	.02	.02	.00	15.
1.01	7.40	92	.07	.05	.01	40.	1.01	19.40	236	.02	.02	.00	15.
1.01	7.45	93	.07	.05	.01	40.	1.01	19.45	237	.02	.02	.00	15.
1.01	7.50	94	.07	.05	.01	40.	1.01	19.50	238	.02	.02	.00	15.
1.01	7.55	95	.07	.05	.01	41.	1.01	19.55	239	.02	.02	.00	15.
1.01	8.00	96	.07	.05	.01	41.	1.01	20.00	240	.02	.02	.00	15.
1.01	8.05	97	.07	.06	.01	41.	1.01	20.05	241	.02	.02	.00	15.
1.01	8.10	98	.07	.06	.01	41.	1.01	20.10	242	.02	.02	.00	15.
1.01	8.15	99	.07	.06	.01	42.	1.01	20.15	243	.02	.02	.00	15.
1.01	8.20	100	.07	.06	.01	42.	1.01	20.20	244	.02	.02	.00	15.
1.01	8.25	101	.07	.06	.01	42.	1.01	20.25	245	.02	.02	.00	15.
1.01	8.30	102	.07	.06	.01	42.	1.01	20.30	246	.02	.02	.00	15.
1.01	8.35	103	.07	.06	.01	43.	1.01	20.35	247	.02	.02	.00	15.
1.01	8.40	104	.07	.06	.01	43.	1.01	20.40	248	.02	.02	.00	15.
1.01	8.45	105	.07	.06	.01	43.	1.01	20.45	249	.02	.02	.00	15.
1.01	8.50	106	.07	.06	.01	43.	1.01	20.50	250	.02	.02	.00	15.
1.01	8.55	107	.07	.06	.01	43.	1.01	20.55	251	.02	.02	.00	15.
1.01	9.00	108	.07	.06	.01	43.	1.01	21.00	252	.02	.02	.00	15.
1.01	9.05	109	.07	.06	.01	44.	1.01	21.05	253	.02	.02	.00	15.

1.01	9.10	110	.07	.06	.01	44.	1.01	21.10	254	.02	.02	.00	15.
1.01	9.15	111	.07	.06	.01	44.	1.01	21.15	255	.02	.02	.00	15.
1.01	9.20	112	.07	.06	.01	44.	1.01	21.20	256	.02	.02	.00	15.
1.01	9.25	113	.07	.06	.01	44.	1.01	21.25	257	.02	.02	.00	15.
1.01	9.30	114	.07	.06	.01	44.	1.01	21.30	258	.02	.02	.00	15.
1.01	9.35	115	.07	.06	.01	44.	1.01	21.35	259	.02	.02	.00	15.
1.01	9.40	116	.07	.06	.01	45.	1.01	21.40	260	.02	.02	.00	15.
1.01	9.45	117	.07	.06	.01	45.	1.01	21.45	261	.02	.02	.00	15.
1.01	9.50	118	.07	.06	.01	45.	1.01	21.50	262	.02	.02	.00	15.
1.01	9.55	119	.07	.06	.01	45.	1.01	21.55	263	.02	.02	.00	15.
1.01	10.00	120	.07	.06	.01	45.	1.01	22.00	264	.02	.02	.00	15.
1.01	10.05	121	.07	.06	.01	45.	1.01	22.05	265	.02	.02	.00	15.
1.01	10.10	122	.07	.06	.00	45.	1.01	22.10	266	.02	.02	.00	15.
1.01	10.15	123	.07	.06	.00	45.	1.01	22.15	267	.02	.02	.00	15.
1.01	10.20	124	.07	.06	.00	45.	1.01	22.20	268	.02	.02	.00	15.
1.01	10.25	125	.07	.06	.00	45.	1.01	22.25	269	.02	.02	.00	15.
1.01	10.30	126	.07	.06	.00	46.	1.01	22.30	270	.02	.02	.00	15.
1.01	10.35	127	.07	.06	.00	46.	1.01	22.35	271	.02	.02	.00	15.
1.01	10.40	128	.07	.06	.00	46.	1.01	22.40	272	.02	.02	.00	15.
1.01	10.45	129	.07	.06	.00	46.	1.01	22.45	273	.02	.02	.00	15.
1.01	10.50	130	.07	.06	.00	46.	1.01	22.50	274	.02	.02	.00	15.
1.01	10.55	131	.07	.06	.00	46.	1.01	22.55	275	.02	.02	.00	15.
1.01	11.00	132	.07	.06	.00	46.	1.01	23.00	276	.02	.02	.00	15.
1.01	11.05	133	.07	.06	.00	46.	1.01	23.05	277	.02	.02	.00	15.
1.01	11.10	134	.07	.06	.00	46.	1.01	23.10	278	.02	.02	.00	15.
1.01	11.15	135	.07	.06	.00	46.	1.01	23.15	279	.02	.02	.00	15.
1.01	11.20	136	.07	.06	.00	46.	1.01	23.20	280	.02	.02	.00	15.
1.01	11.25	137	.07	.06	.00	46.	1.01	23.25	281	.02	.02	.00	15.
1.01	11.30	138	.07	.06	.00	46.	1.01	23.30	282	.02	.02	.00	15.
1.01	11.35	139	.07	.06	.00	46.	1.01	23.35	283	.02	.02	.00	15.
1.01	11.40	140	.07	.06	.00	46.	1.01	23.40	284	.02	.02	.00	15.
1.01	11.45	141	.07	.06	.00	47.	1.01	23.45	285	.02	.02	.00	15.
1.01	11.50	142	.07	.06	.00	47.	1.01	23.50	286	.02	.02	.00	15.
1.01	11.55	143	.07	.06	.00	47.	1.01	23.55	287	.02	.02	.00	15.
1.01	12.00	144	.07	.06	.00	47.	1.02	.00	288	.02	.02	.00	15.
									SUM	32.17	30.45	1.73	22816.
										(817.)(773.)(44.)(646.08)			

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1392.	257.	79.	79.	22839.
CMS	39.	7.	2.	2.	647.
INCHES		24.61	30.42	30.42	30.42
MM		625.17	772.69	772.69	772.69
AC-FT		127.	157.	157.	157.
THOUS CU M		157.	194.	194.	194.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 1

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	696.	128.	40.	40.	11420.
CMS	20.	4.	1.	1.	323.
INCHES		12.31	15.21	15.21	15.21
MM		312.59	386.35	386.35	386.35

AC-FT 44. 79. 79. 79.

CFS	1392.	257.	79.	79.	22639.
CMS	39.	7.	2.	2.	647.
INCHES		44.61	39.42	39.42	39.42
MM		635.17	772.69	772.69	772.69
AC-FT		127.	157.	157.	157.
THOUS CU M		157.	194.	194.	194.

HYDROGRAPH ROUTING

ROUTE THROUGH SPILLWAY

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPRP	LSTR
.0	.000	.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	.060	.000	.000	-779.	-1

STAGE	779.00	780.75	781.00	781.50	782.00	782.50	783.00	783.50	784.00	784.50
	785.00	785.50								
FLOW	.00	17.00	21.00	31.00	38.00	55.00	67.00	77.00	86.00	91.00
	100.00	106.00								
SURFACE AREA=	0.	12.	14.	44.						
CAPACITY=	0.	47.	60.	339.						
ELEVATION=	767.	779.	780.	790.						

CREL	SPWID	COGW	EXPW	ELEVL	COGL	CAREA	EXPL
779.0	.0	.0	.0	.0	.0	.0	.0

DAM DATA

TOPEL	COGD	EXPD	DAMWID
782.8	.0	.0	0.

CREST LENGTH	0.	60.	185.	315.	365.	437.	662.	905.	1037.	1145.
AT OR BELOW ELEVATION	782.2	782.8	782.9	783.1	783.2	783.4	784.0	784.1	784.7	785.3

STATION 2, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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 .50	RATIO 2 .55	RATIO 3 .60	RATIO 4 .65	RATIO 5 .70	RATIO 6 1.00
HYDROGRAPH AT	1	.10 (.25)	1	696. (19.70)	765. (21.67)	835. (23.64)	905. (25.61)	974. (27.58)	1392. (39.41)
ROUTED TO	2	.10 (.25)	1	65. (1.85)	84. (2.38)	103. (2.93)	135. (3.82)	180. (5.10)	805. (22.81)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	779.00	779.00	782.00
STORAGE	47.	47.	109.
OUTFLOW	0.	0.	94.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	782.56	.00	104.	65.	.00	18.08	.00
.55	782.73	.00	108.	84.	.00	18.00	.00
.60	782.85	.05	110.	103.	1.58	17.33	.00
.65	782.95	.15	112.	125.	2.50	17.08	.00
.70	783.04	.24	114.	180.	2.75	16.00	.00
1.00	783.59	.79	127.	605.	3.33	15.75	.00

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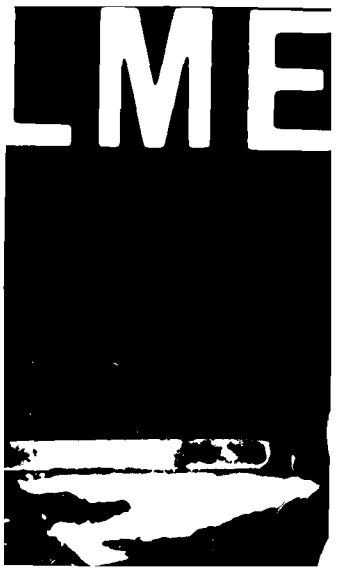
LME