

AD-A106 041

HORNER AND SHIFRIN INC ST LOUIS MO
NATIONAL DAM SAFETY PROGRAM. LAC CATALINA DAM (MO 30286); MISSI--ETC(U)
AUG 79 A B BECKER, K L FREESE, J D HIGGINS DACW43-79-C-0087

F/0 13/13

UNCLASSIFIED

ML

1-1
PAGE 041

11

END

DATE

FILMED

11-81

DTIC

AP A106041

LEVEL II

MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

LAC CATALINA DAM

MO 30286

TERRE DU LAC DEVELOPMENT

ST. FRANCOIS COUNTY, MISSOURI

DTIC
ELECTED
OCT 21 1981
H

PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY INSPECTION

FILE COPY



United States Army
Corps of Engineers

... Serving the Army
... Serving the Nation

St. Louis District

Original contains color
plates. All DTIC reproductions
will be in black and
white.

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

FOR: STATE OF MISSOURI

AUGUST 1979

81 10 21

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
	AD-A106	041
4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Lac Catalina Dam (MO 30286) St. Francois County, Missouri		5. TYPE OF REPORT & PERIOD COVERED Final Report.
7. AUTHOR(s) Horner & Shifrin, Inc.		8. CONTRACT OR GRANT NUMBER(s) DACW43-79-C-0047
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		12. REPORT DATE August 1979
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Albert B. /Becker, Jr. Karl L. /Freese Jerry D. /Higgins		13. NUMBER OF PAGES Approximately 60
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
16. DIS Approved for release; distribution unlimited.		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) National Dam Safety Program. Lac Catalina Dam (MO 30286), Mississippi - Kaskaskia - St. Louis Basin, Terre du Lac Development, St. Francois County, Missouri. Phase I Inspection Report.		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)



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

IN REPLY REFER TO

SUBJECT: Lac Catalina (Mo. 30286) Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Lac Catalina Dam (Mo. 30286).

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

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

1. Spillway will not pass 50 percent of the Probable Maximum Flood.
2. Overtopping of the dam and/or significant erosion of the spillway could result in failure of the dam.
3. Dam failure significantly increases the hazard to loss of life downstream

SUBMITTED BY: SIGNED
Chief, Engineering Division

19 SEP 1979
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer

19 SEP 1979
Date

MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

LAC CATALINA DAM

MO 30286

TERRE DU LAC DEVELOPMENT

ST. FRANCOIS COUNTY, MISSOURI

PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY INSPECTION



**United States Army
Corps of Engineers**

*... Serving the Army
... Serving the Nation*

St. Louis District

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

FOR: STATE OF MISSOURI

AUGUST 1979

LAC CATALINA DAM - MISSOURI INVENTORY NO. 30286

ST. FRANCOIS COUNTY, MISSOURI

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

HORNER & SHIFRIN, INC.
5200 OAKLAND AVENUE
ST. LOUIS, MISSOURI 63110

FOR:

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS

Accession No.	NTIS 67 11	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
DTIC 1	Unclassified	Justification		
By	Dist	By Codes	Date	
A				

AUGUST 1979

HS-7925

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Lac Catalina Dam
State Located:	Missouri
County Located:	St. Francois
Stream:	Tributary Big River
Date of Inspection	5 June 1979

The Lac Catalina Dam, which is located within the Terre Du Lac Subdivision development, was visually inspected by engineering personnel of Horner & Shifrin, Inc., Consulting Engineers, St. Louis, Missouri. The purpose of this inspection was to assess the general condition of the dam with respect to safety and, based upon this inspection and available data, determine if the dam poses a hazard to human life or property.

Lac Catalina, at about 6 acres of surface area, is one of sixteen lakes that have been constructed within the Terre Du Lac Development. Lac Catalina lies approximately 1,300 feet upstream of Lac Carmel, a lake of about 60 acres also within Terre Du Lac. A site plan of the subdivision development showing the relative location of these lakes is presented on Plate 2 of this report.

The following summarizes the findings of the visual inspection and the results of certain hydrologic/hydraulic investigations performed under the direction of the inspection team. Based on the

visual inspection, the present general physical condition of the dam is considered to be satisfactory; however, the following deficiencies were noticed during the inspection and are considered to have an adverse effect on the overall safety and future operation of the dam:

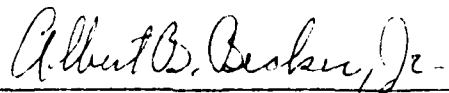
1. Seepage was observed flowing from beneath the lake drawdown conduit at the downstream face of the dam. Uncontrolled seepage can develop into a piping condition that could result in failure of the dam.
2. The spillway discharge channel is moderately eroded throughout with the outlet end of the spillway pipe undercut. Since the location of the spillway channel encroaches on the dam, continued erosion of the channel can result in damage to the embankment that could affect the stability of the dam.
3. The spillway discharge channel at a point just below the outlet end of the spillway pipe contains debris (boards and refuse bags). Unnecessary items within the spillway channel can reduce channel capacity that could result in flooding of the channel and allow spillway releases to impinge on the dam.
4. The upstream face of the dam has a grass cover to prevent erosion. However, at the lake waterline, some minor erosion of the slope has occurred. Continued erosion of the embankment could result in loss of section that may lead to instability of the slope and possible failure of the dam.

5. The upstream and downstream face of the dam are protected from erosion by a grass cover, which at the time of inspection, was approximately 30 inches high. Uncut grass on the dam is an indication of lack of regular maintenance.

According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for the Lac Catalina Dam, which is classified as small in size and of high hazard potential, is specified to be a minimum of one-half the Probable Maximum Flood (PMF). Considering the proposed residential type development as indicated on the Terre Du Lac development plats, immediately downstream of this dam, it is recommended that the spillway be designed for the PMF. The Probable maximum Flood (PMF) is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. Results of a hydrologic/hydraulic analysis indicated that the existing spillway is inadequate to pass lake outflow resulting from a storm of PMF magnitude. The spillway is adequate to pass lake outflow resulting from the 1 percent chance (100 year frequency) flood and lake outflow corresponding to about 39 percent of the PMF. According to the St. Louis District, Corps of Engineers, the length of the downstream damage zone, should failure of the dam occur, extends approximately two miles downstream of the dam. Accordingly, within the possible damage zone, are three dwellings, a road, and Lac Carmel Lake with two dwellings near the shoreline.

A review of available data did not disclose that seepage or stability analyses of this dam was performed. This is considered a deficiency and should be rectified.

It is recommended that the Owner take the necessary action in the near future to correct or control the deficiencies and safety defects reported herein.



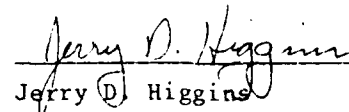
Albert B. Becker, Jr.

P.E. Missouri E-9168



Karl L. Freese

P.E. Missouri E-16182



Jerry D. Higgins

Engineering Geologist



THE END OF THE WORLD

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

LAC CATALINA DAM - ID. NO. 30286

TABLE OF CONTENTS

<u>Paragraph No.</u>	<u>Title</u>	<u>Page No.</u>
SECTION 1 - PROJECT INFORMATION		
1.1	General	1-1
1.2	Description of Project	1-1
1.3	Pertinent Data	1-4
SECTION 2 - ENGINEERING DATA		
2.1	Design	2-1
2.2	Construction	2-1
2.3	Operation	2-1
2.4	Evaluation	2-1
SECTION 3 - VISUAL INSPECTION		
3.1	Findings	3-1
3.2	Evaluation	3-3
SECTION 4 - OPERATIONAL PROCEDURES		
4.1	Procedures	4-1
4.2	Maintenance of Dam	4-1
4.3	Maintenance of Outlet Operating Facilities	4-1
4.4	Description of Any Warning Systems in Effect	4-1
4.5	Evaluation	4-1

<u>Paragraph</u>	<u>Title</u>	<u>Page No.</u>
SECTION 5 - HYDRAULIC/HYDROLOGIC		
5.1	Evaluation of Features	5-1
SECTION 6 - STRUCTURAL STABILITY		
6.1	Evaluation of Structural Stability	6-1
Section 7 - ASSESSMENT/REMEDIAL MEASURES		
7.1	Dam Assessment	7-1
7.2	Remedial Measures	7-2

LIST OF PLATES AND CHARTS

<u>Plate No.</u>	<u>Title</u>
1	Regional Vicinity Map
2	Terre Du Lac - Site Plan
3	Subdivision Plat (Partial)
4	Lake Watershed Map
5	Lac Catalina Dam - Plan and Profile
6	Lac Catalina - Dam Section and Spillway Profile
7	Area-Storage Volume Curves
8	Spillway Discharge Rating Curve

APPENDIX A - INSPECTION PHOTOGRAPHS

<u>Page No.</u>	<u>Title</u>
A-1 through A-4	Inspection Photographs

APPENDIX B - HYDROLOGIC AND HYDRAULIC ANALYSES

<u>Page No</u>	<u>Title</u>
B-1	Hydrologic and Hydraulic Computations
B-2 through B-4	Computer Input Data
B-5	Summary Dam Safety Analysis
B-6	PMF Hydrographs

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

LAC CATALINA DAM - ID NO. 30286

SECTION I - PROJECT INFORMATION

1.1 GENERAL

a. Authority. National Dam Inspection Act, Public Law 92-367, dated 8 August 1972.

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

c. Evaluation of Criteria. This evaluation was performed in accordance with the "Phase I" investigation procedures as prescribed in "Recommended Guidelines for Safety Inspection of Dams," Appendix D to "Report of the Chief of Engineers on the National Program of Dams," dated May 1975.

1.2 DESCRIPTION OF PROJECT

a. General. Lac Catalina is one of a group of lakes, within the development known as Terre Du Lac, and located near the upstream end of an unnamed tributary of Big River. A second lake within the Terre Du Lac development, Lac Carmel, also lies on this same tributary approximately 1,300 feet downstream of the Lac Catalina dam. A site plan showing the Terre Du Lac development, including Lac Catalina is shown on Plate 2.

- b. Description of Dam and Appurtenances. The Lac Catalina Dam is an earthfill type embankment rising approximately 30 feet above the original stream bed. The embankment has an upstream slope (above the waterline) of 1v on 3.9h, a crest width of about 30 feet, and a downstream slope of about 1v on 2.2h. The length of the dam is approximately 422 feet and an unpaved road traverses the dam crest. A plan and profile of the dam are shown on Plate 5 and a cross-section of the dam is shown on Plate 6.

The spillway, a 72-inch wide by 44-inch high corrugated metal pipe section about 50 feet long, passes through the dam near the west or left abutment. The spillway discharge channel, an unimproved section of variable width, follows roughly the intersection of the downstream face of the embankment and the left abutment until it reaches the area below the dam where it joins the downstream channel. A profile of the channel invert through the spillway pipe is also shown on Plate 6.

A 6-inch diameter pipe with a control valve near the upstream end is provided for lowering the lake approximately 4.4 feet. At normal pool elevation the lake occupies approximately 6 acres.

- c. Location. The Lac Catalina is located in Section 19, Township 37 North, Range 4 East, of St. Francois County, Missouri. The dam lies within the subdivision known as Terre Du Lac, the entrance to which is located on the south side of State Highway 47 about four miles west of the City of Bonne Terre, as shown on the Regional Vicinity Map, Plate 1.
- d. Size Classification. The size classification of this dam, based on the height of the dam and its storage capacity and

categorized according to Table 1, "Recommended Guidelines for Safety Inspection of Dams," is small.

- e. Hazard Classification. Lac Catalina Dam, according to the St. Louis District, Corps of Engineers, has a high hazard potential. A high hazard classification means that the dam is located where failure may cause loss of life, serious damage to homes, extensive damage to agricultural, industrial and commercial facilities, important public utilities, main highways, or railroads. According to the Corps of Engineers, the estimated length of the flood damage zone, should failure of the dam occur, extends approximately two miles downstream of the dam. Within the possible damage zone are three dwellings, a road, and Lac Carmel Lake with two dwellings near the shoreline.
- f. Ownership. The Terre Du Lac Development, including the Lac Catalina Dam, is owned by Sensibar Enterprises, Inc., 120 S. La Salle, Chicago, Illinois - 60603. The Owner's local representative is Mr. James Kwon, Jr. It was reported that Sensibar Enterprises, Inc., purchased the development from the original owner, Terre Du Lac, Inc., in 1976.
- g. Purpose of Dam. The dam impounds water for the purpose of recreation for surrounding residential property owners who live within the Terre Du Lac development.
- h. Design and Construction History. The Lac Catalina Dam was constructed in 1971 by the former owner-builder, the Big River Lakes Development Corporation, Inc., and the Fred Weber Contracting Company. According to a representative of the Owner, the designer of the dam was James B. Bennett, an engineer in the employ of the former owner. According to Mr. Bennett the dam is a homogeneous earthfill embankment with a core trench cutoff to rock.

- i. Normal Operational Procedures. The lake level is unregulated.

1.3 PERTINENT DATA

a. Drainage Areas. Due to the planned development in the vicinity of the lake, the areas tributary to the lake is considered to be primarily suburban residential. The watershed area above the dam amounts to approximately 56 acres. The watershed area is outlined on Plate 4.

b. Discharge at Damsite.

- (1) Estimated known maximum flood at damsite ... 26 cfs*.
- (2) Spillway capacity ... 98 cfs (W.S. elevation 937.6).

c. Elevation (ft. above MSL). The upstream invert elevation for the spillway pipe was provided by a representative of the Owner. The elevation of the top of the dam was determined by survey at the time of the inspection.

- (1) Top of dam ... 937.6 (min)
- (2) Normal pool ... 933.6
- (3) Streambed at centerline of dam ... 907₊
- (4) Maximum observed tailwater ... No data available

d. Reservoir.

- (1) Length at normal pool (elev. 933.6) ... 950 ft.
- (2) Length at maximum pool (elev. 937.6) ... 1,150 ft.

* Based on an estimate of depth of flow at spillway per a representative of the Owner.

e. Storage.

- (1) Normal pool ... 71 ac. ft.
- (2) Top of dam (incremental) ... 29 ac.ft.

f. Reservoir Surface.

- (1) Normal pool ... 6 acres.
- (2) Top of dam ... 10 acres.

g. Dam.

- (1) Type ... Earthfill, homogeneous *
- (2) Length ... 422 ft.
- (3) Structural height ... 30 ft.
- (4) Top width ... 30 ft.
- (5) Side slopes
 - (a) Upstream ... 1v on 3.9h (above waterline)
 - (b) Downstream ... 1v on 2.2h
- (6) Cutoff ... core trench*
- (7) Slope protection
 - (a) Upstream ... grass
 - (b) Downstream ... grass

h. Spillway.

- (1) Type ... Uncontrolled, 72-inch by 44-inch corrugated metal pipe arch
- (2) Length ... 50 ft.
- (3) Elevation ... 933.6 (ft. above MSL)
- (4) Approach channel ... Lake
- (5) Discharge channel ... trapezoidal section with riprap below pipe, earth cut.

* Per representative of the Owner.

i. Outlet for Lake Drawdown.

- (1) Size ... 6-inch PVC pipe at outlet.
- (2) Control ... Valve
- (3) Elevation (ft. above MSL.) ... 929.2₊.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Engineering data relating to the design of the dam were not available for review. As previously indicated, the dam was designed by James B. Bennett, an engineer formerly in the employ of the Owner. According to Mr. Bennett, the dam is a homogeneous earthfill embankment with a clay core cutoff.

2.2 CONSTRUCTION

According to a representative of the Owner, construction of the dam was completed in 1971. Records of the construction activities were not available for review. According to Mr. Bennett, the dam was constructed by the Fred Weber Contracting Company. Excavation was carried to rock for a clay core cutoff along the centerline of the dam. Clay fill was placed in uniform lifts and compacted with a sheepsfoot roller.

2.3 OPERATION

The lake level is governed by overflow of an uncontrolled pipe type spillway. According to a representative of the Owner the dam has never been overtopped and based on an estimate of the depth of flow at the spillway, the maximum known loading on the dam was produced by a storm that raised the level of the lake about 0.7 foot above normal pool level.

2.4 EVALUATION

a. Availability. Engineering data for assessing the design of the dam and spillway were not available.

b. Adequacy. No design data available. 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. Detailed seepage and stability analysis should be performed as required by the guidelines and made a matter of record.

SECTION 3 - VISUAL INSPECTION

3.1. FINDINGS

a. General. A visual inspection of the Lac Catalina Dam was made by Horner & Shifrin engineering personnel, K.L. Freeze, Civil Engineer and Hydrologist, and A.B. Becker, Jr., Civil and Soils Engineer, on 5 June 1979. An examination of the dam site was also made by an engineering geologist, Jerry D. Higgins, a consultant retained by Horner & Shifrin for the purpose of assessing the area geology. Also examined at the time of the inspection, was the area below the dam within the potential flood damage zone. Photographs of the dam taken at the time of the inspection are included on Pages A-1 through A-4 of Appendix A.

b. Geology. The dam site is located on the northern flank of the Ozark Dome on nearly flat-lying Cambrian age rock between branches of the Big River fault. The fault trends northeast-southwest passing approximately 1-1/2 miles to the southeast. A branch of this fault trends east-west and passes approximately 2 miles to the north of the dam. In the general area of the lake, Cambrian age Potosi and Derby-Doerun formations are exposed at the surface. The Potosi formation is a massive, thickly-bedded, medium-to fine-grained dolomite with abundant quartz druse and chert. The Derby-Doerun formation is a tan to buff, thin-to medium-bedded, argillaceous dolomite.

The dam site and lake are founded on Potosi residuum. The residuum derived from insitu weathering is a blocky, red clay abundant in quartz druse and chert.

There has been no severe erosion of residuum around the lake, although considerable erosion of the residuum has occurred immediately downstream of the right abutment from surface drainage

runoff. The reported faults in the area do not cross the dam site and are considered inactive. No adverse geologic conditions conducive to leakage or dam stability were evident at the site.

c. Dam. The visible portions of the upstream and downstream faces of the dam (see Photos 1 and 2) appeared to be in sound condition although some minor erosion of the unprotected upstream slope at the waterline was noticed. The downstream slope had a dense cover of grass that was about 30 inches high at the time of the inspection. The roadway that traverses the dam crest was surfaced with gravel that was thinly distributed and some rutting of the surface was observed.

The 44-inch high by 72-inch wide corrugated metal spillway pipe appeared to be in satisfactory conditions (see Photos 3 and 4), although the downstream end of the pipe was unsupported for a distance of about 2 feet. A concrete apron, about 5 feet long and in good condition, serves to prevent erosion at the lake approach to the spillway pipe. At a point below the outlet end of the spillway pipe, debris, consisting of large boards and refuse bags, (see Photo 4) was lodged in the channel. Stone riprap up to 5 cubic feet in size has been placed within the channel section for a distance of about 60 feet below the spillway pipe. Downstream and within the riprap protected section, the banks of the spillway channel (see Photo 5) were noticeably eroded in several locations.

The exposed end of the 6-inch PVC lake drawdown pipe (see Photo 6) appeared to be in good condition, however, a curb box for the valve, reported to be near the upstream end of the pipe, was not seen. Seepage on the order of about 1 gpm was noticed emerging from the embankment (see Photo 7) at the point where the 6-inch pipe daylights. Seepage from the lake drawdown pipe drains across the face of the embankment for about 15 feet before entering the spillway discharge channel.

d. Downstream Channel. The channel downstream of the dam is unimproved and extends for approximately 1,200 feet before joining the upstream end of Lac Carmel.

e. Reservoir. The area surrounding the lake is in various stages of residential development. An 8-inch cast-iron pipe sewer (see Photo 8) crosses the lake near the upstream end, and at the time of the inspection sewer construction work was in progress at the south side of the road just upstream of the lake. Although the lake water was slightly off-color, no appreciable sediment was noticed within the lake at the upstream end or along the shoreline.

3.2. EVALUATION

The deficiencies observed during this inspection are not considered significant to warrant immediate remedial action.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The spillway is uncontrolled. The water surface level is governed by precipitation runoff, evaporation, seepage, and the capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM

Based on the general condition of the spillway discharge channel (debris and trash bags were found in the channel just below the spillway pipe and the section is noticeably eroded in several locations), the through seepage at the lake drawdown pipe, and the fact that the grass on the dam has not been mowed recently, it is evident that these areas receive little attention. According to a representative of the Owner, maintenance work is performed only when considered necessary.

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

No outlet operating facilities exist at this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEMS IN EFFECT

The inspection did not reveal the existence of a dam warning system.

4.5 EVALUATION

A poorly maintained dam is considered detrimental to the safety of the dam. It is recommended that maintenance of the dam, including the spillway outlet channel, be undertaken on a regular basis.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. There were no hydraulic and hydrologic design data available as discussed in Section 2.

b. Experience Data. The drainage area and lake surface area were developed from the USGS Mineral Point, Missouri, Quadrangle Map. The spillway and dam layout were developed from surveys made during the inspection.

c. Visual Observations.

- (1) The spillway consists of a 72-inch wide by 44-inch high corrugated metal pipe approximately 50 feet long.
- (2) The spillway is located within the embankment near the left (west) abutment.
- (3) The spillway outlet channel follows the intersection of the embankment and the abutment. The upper section of channel is protected from erosion by stone riprap. Since the spillway channel encroaches on the embankment, it is possible that spillway releases could damage the dam. A profile of the spillway channel invert is shown on Plate 6.
- (4) A conduit consisting of a 6-inch pipe with a valve near the upstream end is provided to lower the lake level approximately 4.4 feet.

c. Overtopping Potential. The pipe spillway is inadequate to pass the probable maximum flood or the 1/2 probable maximum flood without overtopping the dam. It is adequate however, to pass the 1 percent chance (100-year frequency) flood without overtopping the dam. The results of a dam overtopping analysis are as follows:

<u>Ratio of PMF</u>	<u>Q-Peak Outflow (cfs)</u>	<u>Max. Lake W.S. Elev.</u>	<u>Max. Depth of Flow over Dam (Elev. 937.6)</u>	<u>Duration of Overtopping of Dam (Hours)</u>
0.40	100	937.65	0.1	0.7
0.50	202	938.2	0.6	2.8
1.0	1,153	939.2	1.6	5.3
100 Yr. Flood	36	935.5	0	0

The flow safely passing the spillway just prior to overtopping amounts to about 98 cfs, which is equivalent to about 39 percent of the probable maximum flood inflow, and greater than the outflow from the 1 percent chance (100-year frequency) flood. Elevation 937.6 was found to be the lowest point in the dam crest. At peak flow of 1/2 the probable maximum flood the greatest depth of flow over the dam would be 0.6 foot and the overflow would extend for about 160 feet across the center of the dam. During the peak flow of the probable maximum flood the greatest depth over the dam would be 1.6 feet and the overflow would extend for about 350 feet across the center of the dam.

Based on knowledge of materials used to construct the dam and confirmed by soil samples (gravelly, red clay of medium to high plasticity) obtained at the dam site, failure of the dam due to minor overtopping is not expected. However, for the PMF condition where the depth of flow overtopping the dam (1.6 feet maximum) and the duration of flow over the dam (5.3 hours) are appreciable, failure of the dam due to overtopping is a possibility.

d. Evaluation. Based on observations made elsewhere within the Terre Du Lac development (the spillway outlet channels for Lac Bourbon and Lac Michel are extensively eroded) and since the spillway outlet channel encroaches on the dam, it appears that the embankment material (gravelly, red clay) can under certain circumstances be very erodible. When large quantities of flow occur over the top of

the dam and especially through the spillway, the flow velocities will increase and produce conditions conducive to rapid erosion. For this dam a condition can develop which could result in serious loss of the dam section by erosion near the abutment where the spillway is located.

f. References. Procedures and data for determining the probable maximum flood, the 100-year frequency flood, and the discharge rating curve for flow over the spillway and the dam crest are presented on Page B-1 of the Appendix. A listing of the HEC-1 (Dam Safety Version) input data is shown on pages B-2 through B-4 of the Appendix. A copy of the computer output table entitled "Summary of Dam Safety Analysis" is presented on Page B-5 and the inflow and outflow hydrographs for the probable maximum flood are shown on Page B-6 of the Appendix. Area-storage volume curves for the reservoir are shown on Plate 7 and a spillway discharge rating curve is presented on Plate 8.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations which adversely affect the structural stability of the dam are discussed in Section 3, paragraph 3.c.

b. Design and Construction Data. Design or construction data relating to the structural stability of the dam were not available for review.

c. Operation Records. No appurtenant structures or facilities requiring operation exist at this dam. According to a representative of the Owner, no records are kept of lake level, spillway discharge, dam settlement, or seepage. Seepage and stability analyses comparable to the requirements of the guidelines are not on record. This is a deficiency which should be rectified.

d. Post Construction Changes. According to a representative of the Owner, no post construction changes were made which would affect the structural stability of the dam.

e. Seismic Stability. Since the dam is located within a Zone II seismic probability area, and since the known geologic faults that lie within the nearby surrounding area are considered inactive, an earthquake of the magnitude predicted is not expected to produce a hazardous condition to the dam, provided that static stability conditions are satisfactory and conventional safety margins exist.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. A hydraulic analysis indicated the pipe spillway to be capable of passing lake outflow of about 98 cfs without the level of the lake exceeding the low point in the top of the dam. A hydrologic analysis of the lake watershed area, as discussed in Section 5, paragraph 5.1d, indicated that for a storm runoff of probable maximum flood magnitude, the lake outflow would be on the order of 1,150 cfs, and that for the 1 percent chance (100-year frequency) flood, the lake outflow would be about 40 cfs.

Items noticed during the inspection that could affect the safety of the dam are seepage, at the drawdown pipe, and erosion at the upstream face of the dam and at the spillway outlet channel.

Stability and seepage analyses of the dam were not available for review and therefore no judgment could be made with respect to the structural stability of the dam.

b. Adequacy of Information. Due to lack of engineering and construction data, the assessments reported herein were based on external conditions as determined during the visual inspection. The assessment of the hydrology of the watershed and capacity of the spillway were based on a hydrologic/hydraulic study as indicated in Section 5. 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. The items concerning the safety of the dam noted in paragraph 7.1a and the remedial measures recommended in paragraph 7.2 should be pursued on a high priority basis.

d. Necessity for Phase II. Based on the results of the Phase I inspection, a Phase II investigation is not recommended.

e. Seismic Stability. Since the dam is located within a Zone II seismic probability area, and since the known geologic faults that lie within the nearby surrounding area are considered inactive, an earthquake of the magnitude predicted is not expected to produce a hazardous condition to the dam, provided that static stability conditions are satisfactory and conventional safety margins exist.

7.2 REMEDIAL MEASURES

a. Recommendations. The following actions are recommended:

(1) Based upon criteria set forth in the recommended guidelines, alterations to the design of the dam should be made in order to pass lake outflow resulting from a storm of probable maximum flood magnitude.

(2) Obtain the necessary soil data and perform dam stability and seepage analyses in order to determine the structural stability of the dam for all operational conditions. Seepage and stability analyses should be performed by a qualified professional engineer experienced in the design and construction of dams.

b. Operations and Maintenance (O & M) Procedures. The following O & M procedures are recommended:

(1) Remove the debris (boards, trash bags, etc.) from the spillway discharge channel that will reduce the capacity of the channel and possibly result in spillway releases impinging on the dam.

(2) Restore the eroded areas of the spillway channel and provide some form of protection along the dam side of the channel in

order to prevent future erosion of embankment materials by spillway flows.

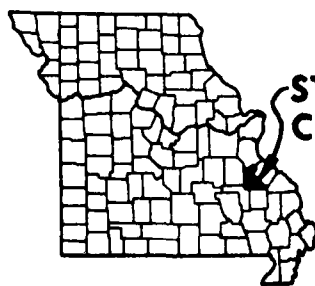
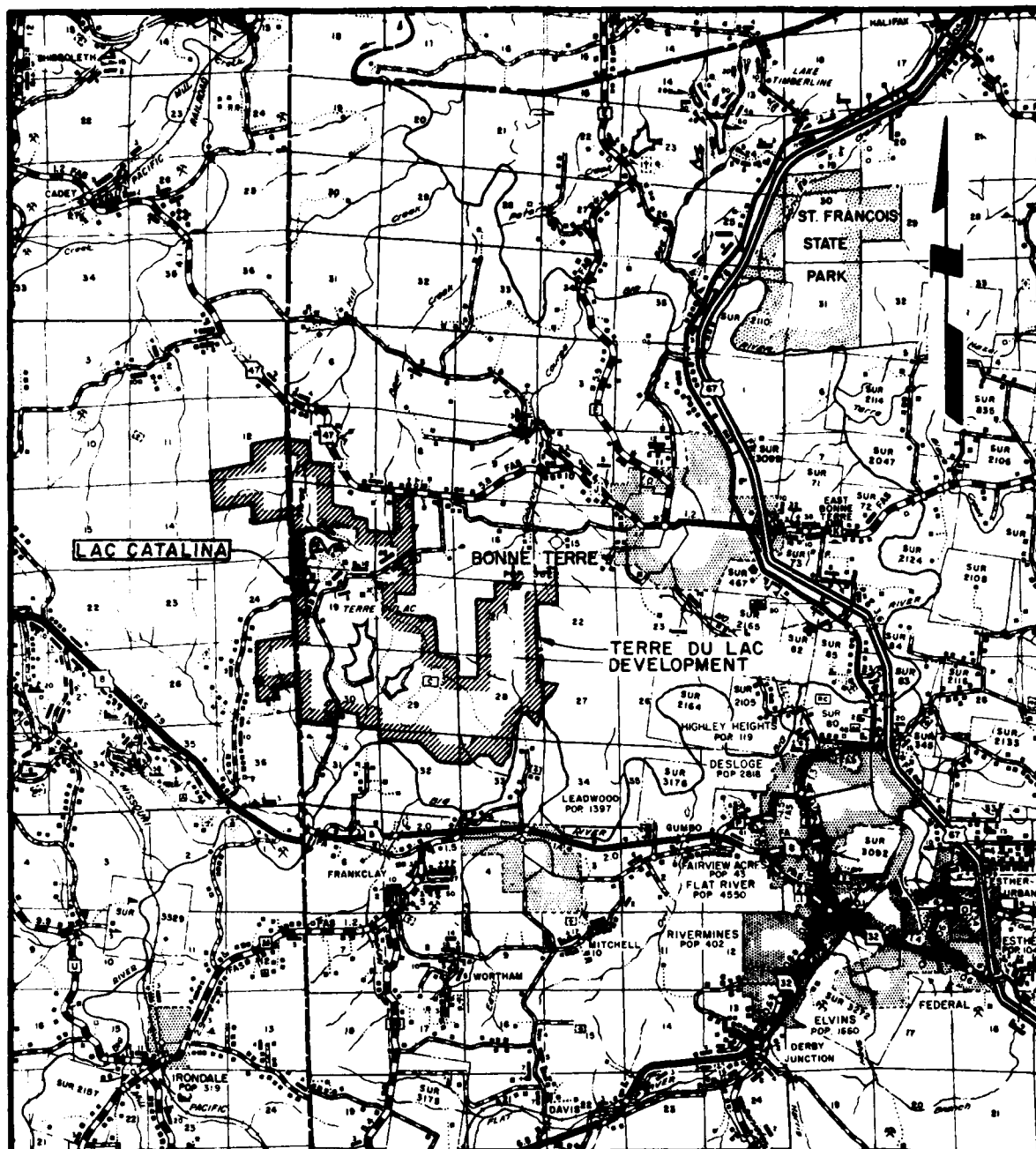
(3) Provide some means of preventing piping (progressive internal erosion) due to seepage at the downstream face of the dam at the drawdown pipe location. A piping condition can result in failure of the dam.

(4) Locate and inspect the valve on the lake drawdown pipe in order to insure serviceability of this feature. Some means should be provided to protect the valve and insure its future operation.

(5) Restore the upstream face of the dam and provide some form of protection for the dam face at and above the normal waterline in order to prevent erosion by wave action.

(6) Provide maintenance of all areas of the dam and spillway on a regularly scheduled basis in order to insure features of being in satisfactory operational condition.

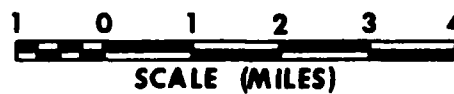
(7) A detailed inspection of the dam should be instituted on a regular basis by an engineer experienced in the design and construction of dams. It is also recommended, for future reference, that records be kept of all inspections made and remedial measures taken.



**ST. FRANCOIS
COUNTY**

LOCATION MAP

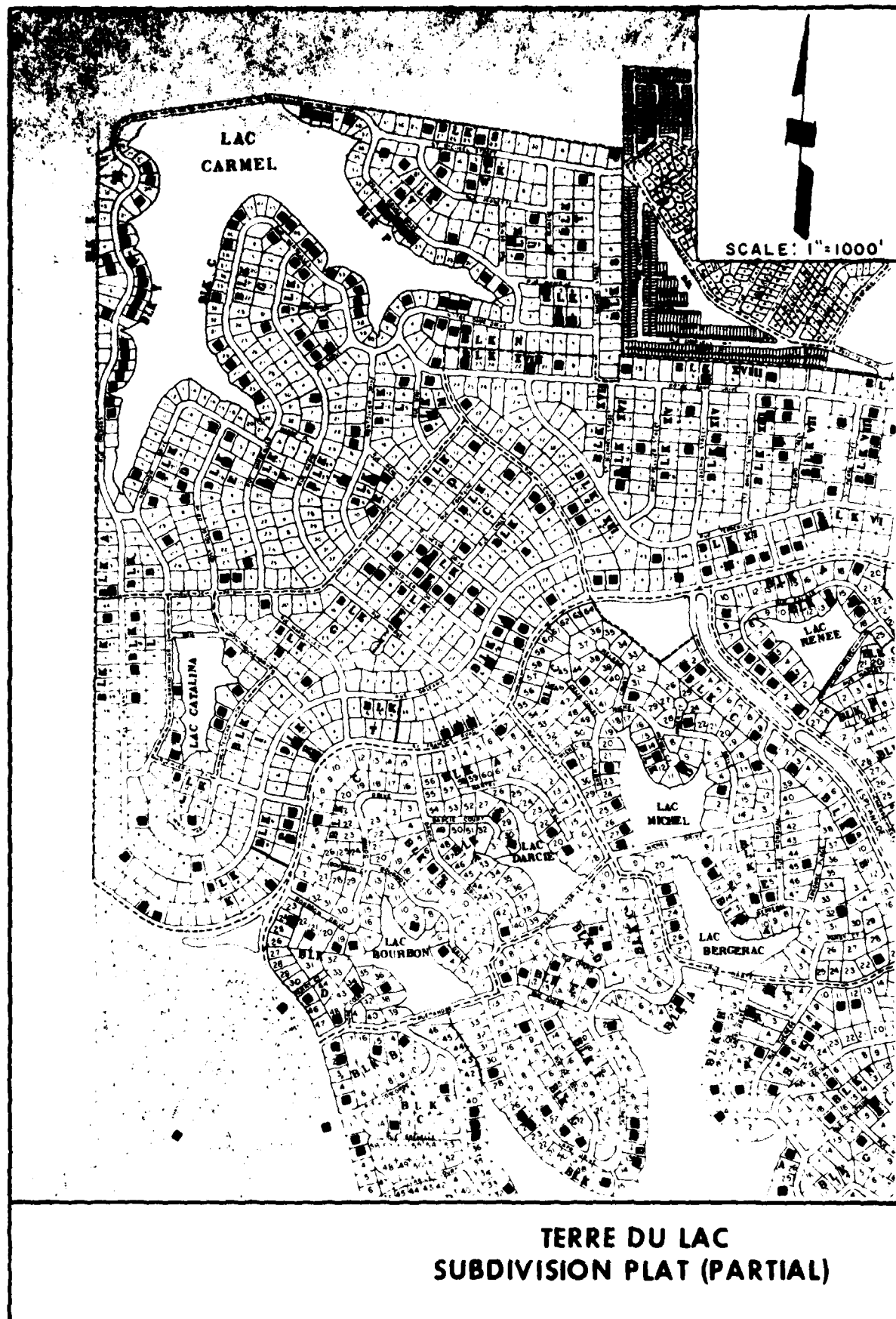
REGIONAL VICINITY MAP

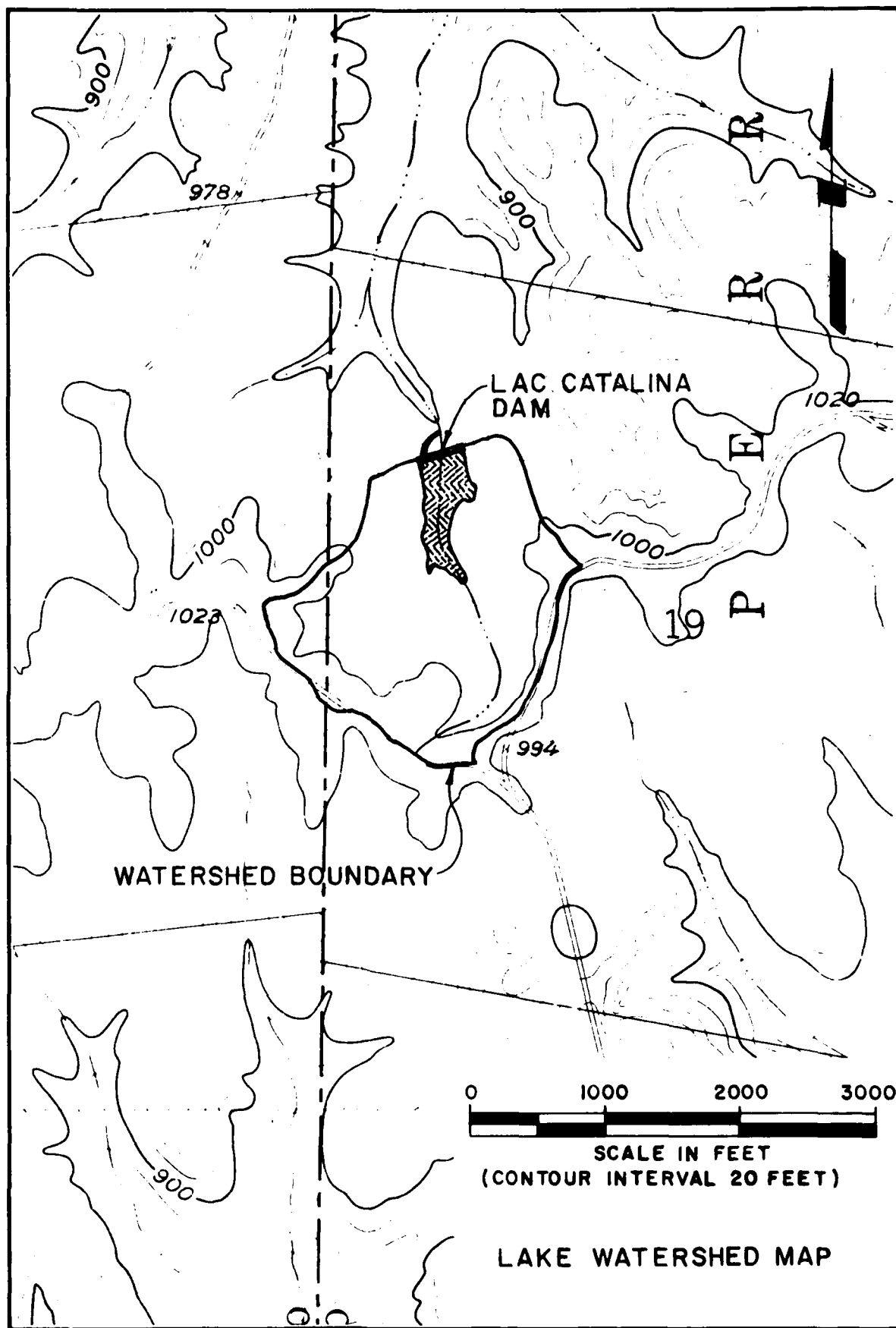


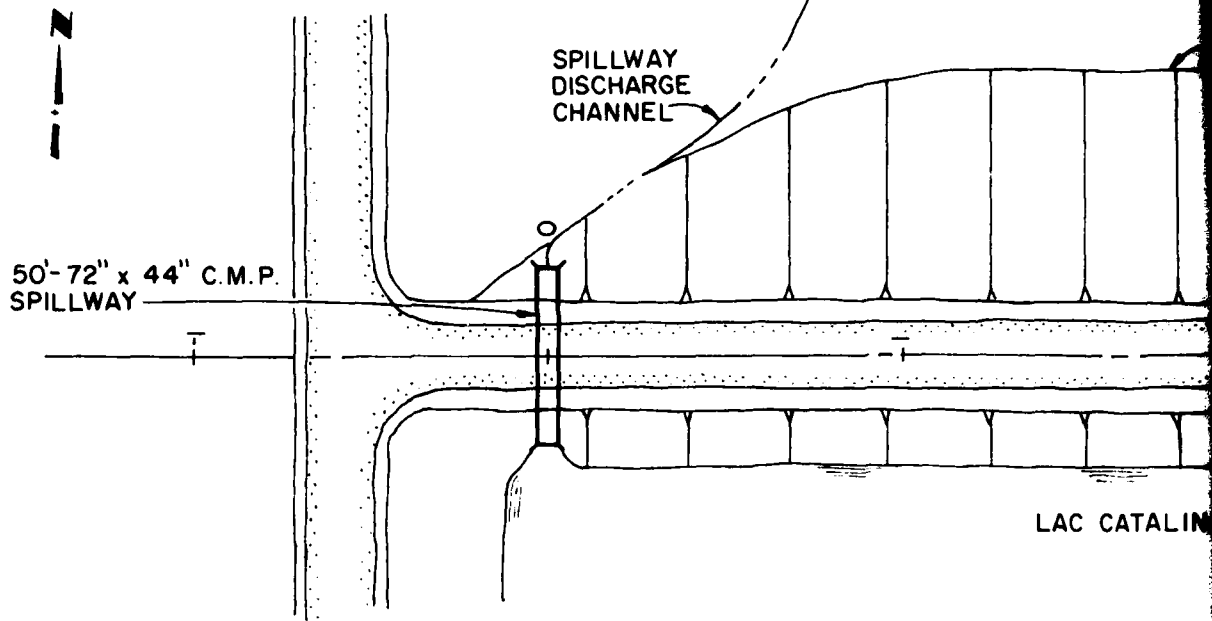
SCALE (MILES)



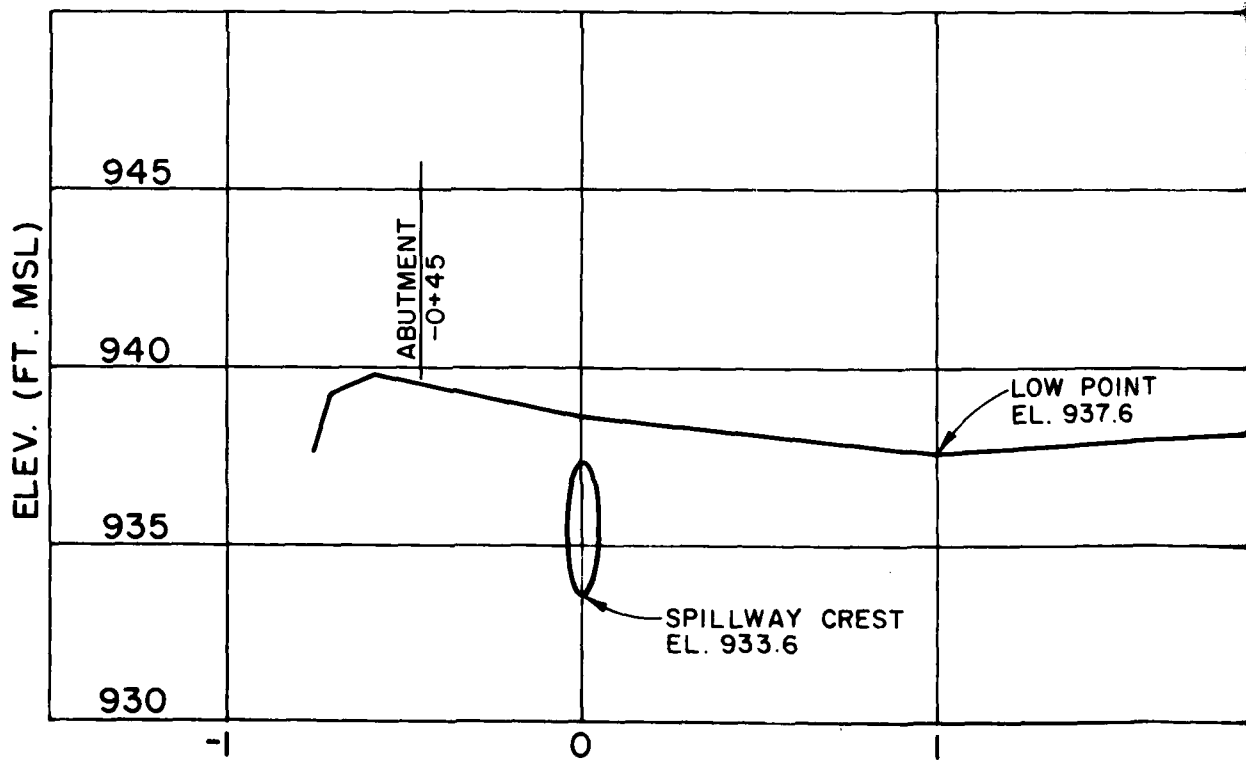
TERRE DU LAC SITE PLAN



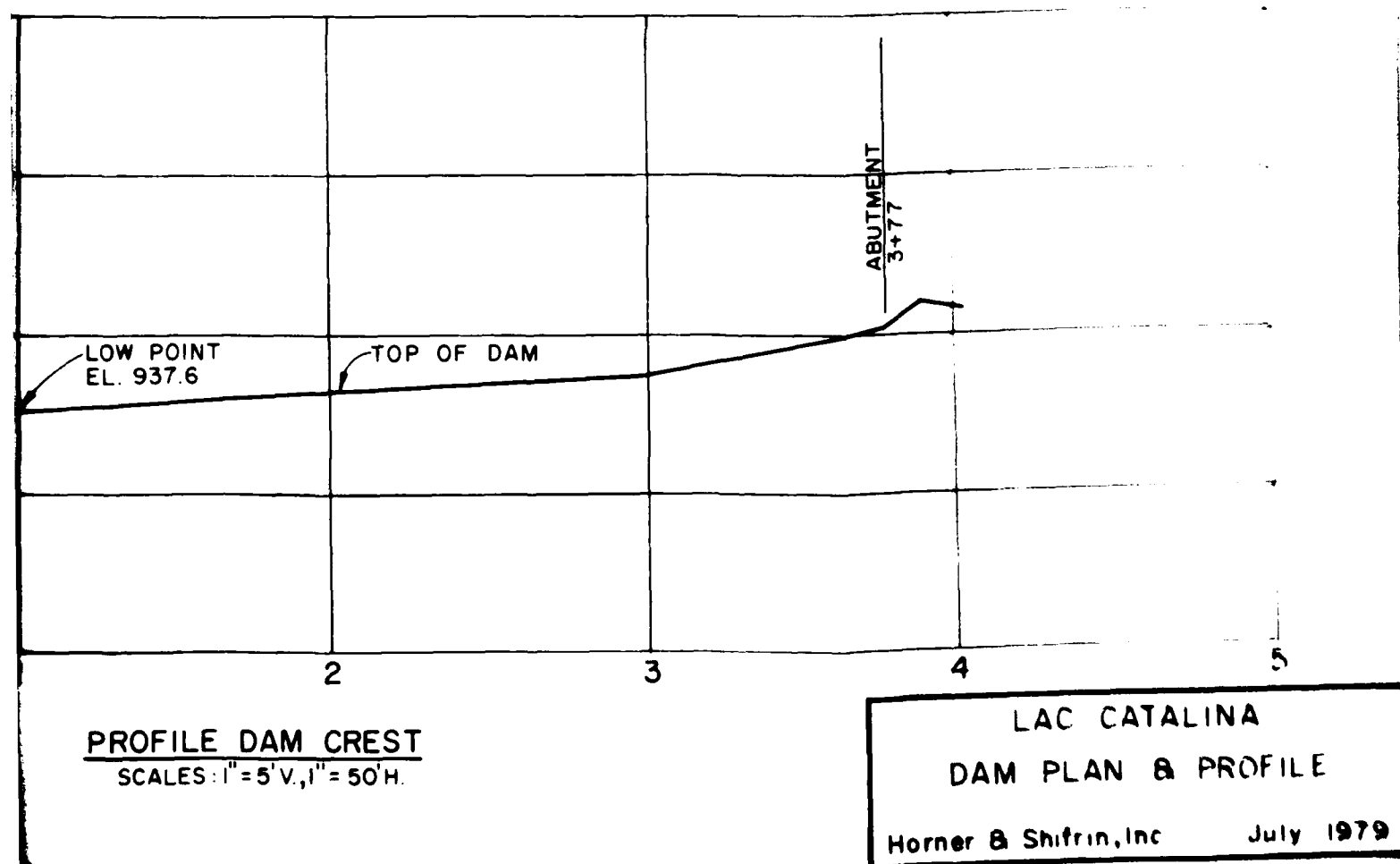
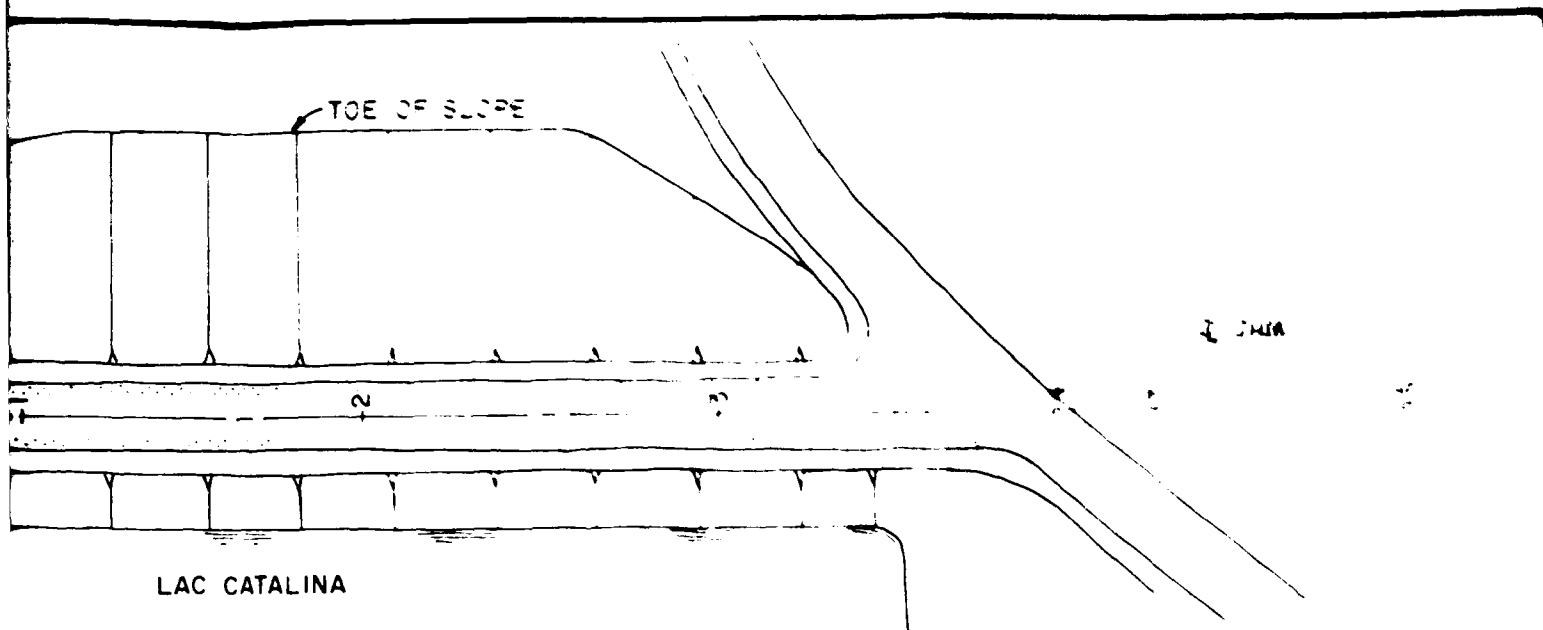


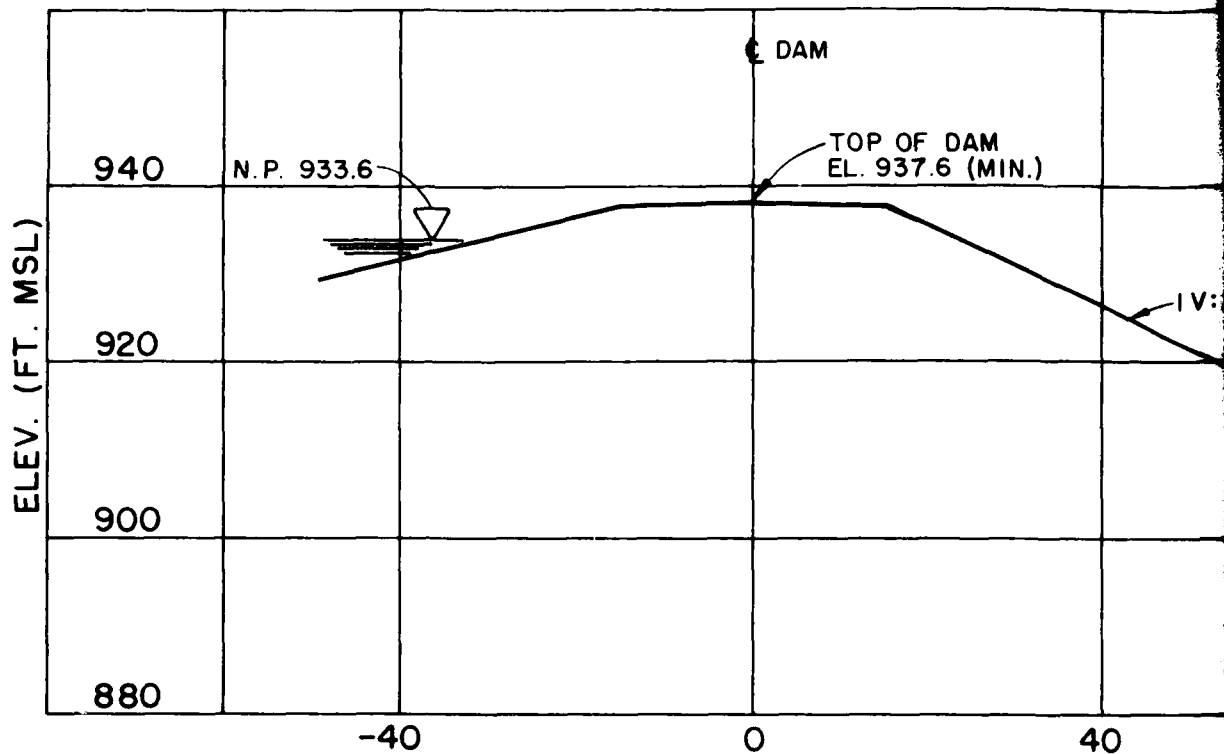


GENERAL
SCALE

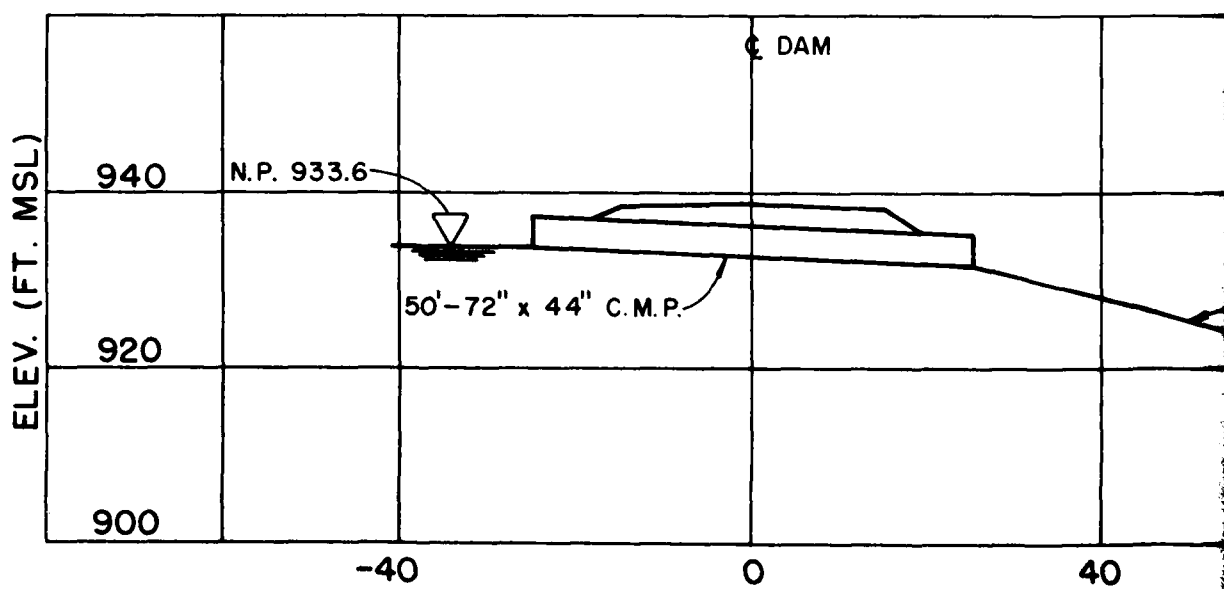


PROFILE DAM
SCALE: 1" = 5' V.

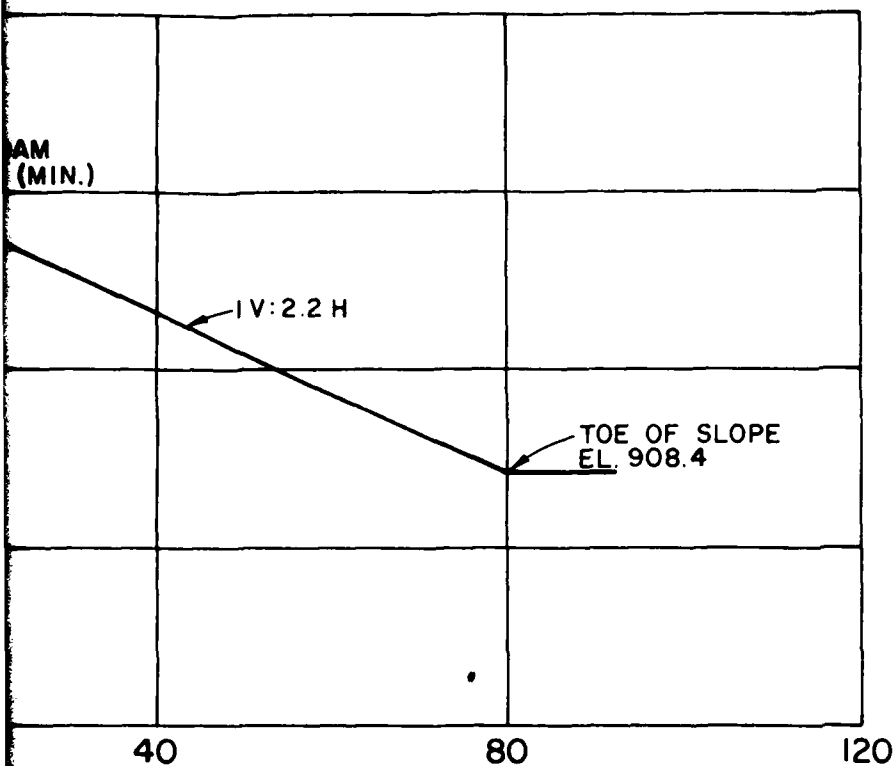




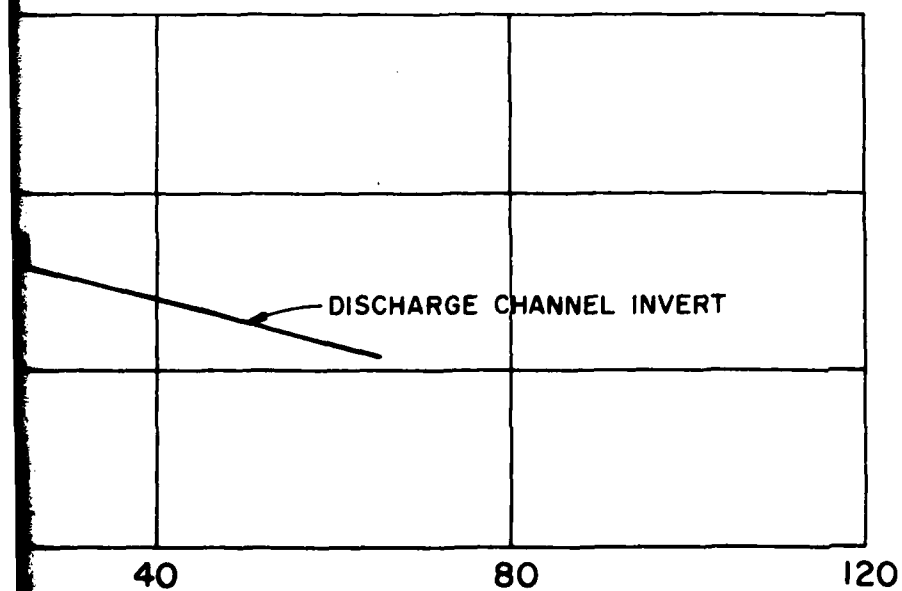
DAM CROSS SECTION STA. 2+58
SCALE 1" = 20'



PROFILE SPILLWAY ∇
SCALE 1" = 20'

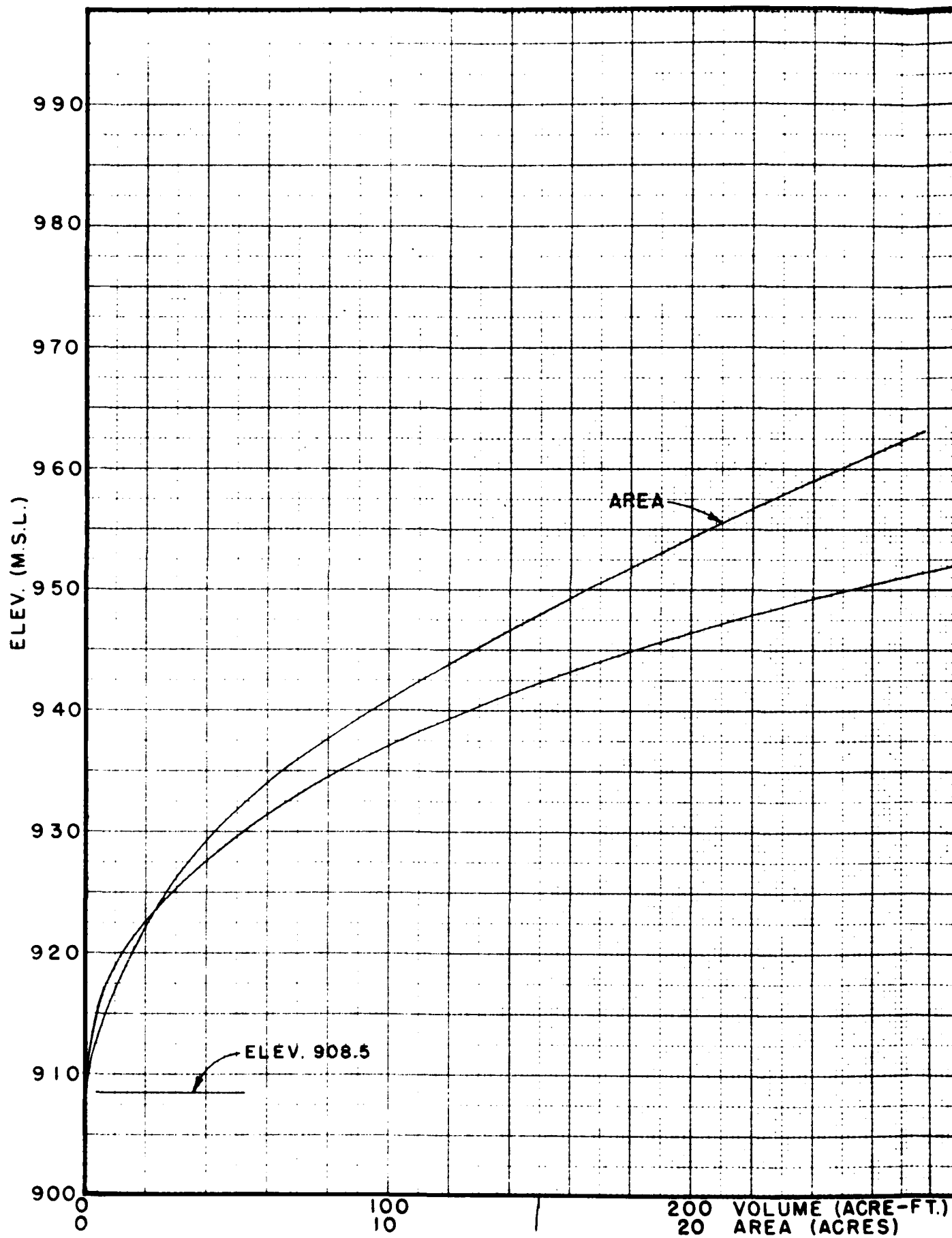


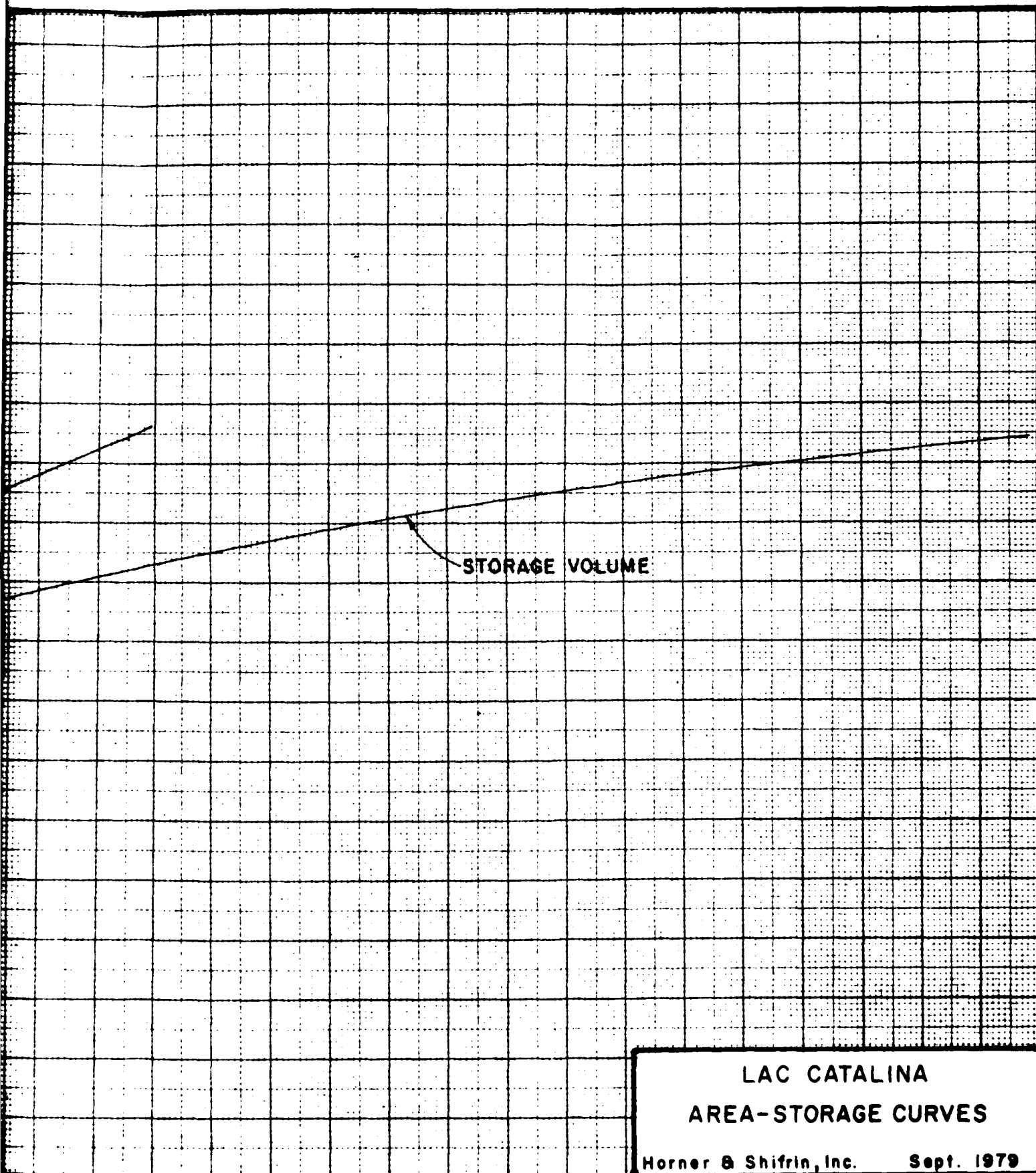
ON STA. 2+58
20'



WAY C
20'

LAC CATALINA
DAM CROSS SECTION &
SPILLWAY PROFILE
Horner & Shifrin, Inc. July 1979





LAC CATALINA
AREA-STORAGE CURVES

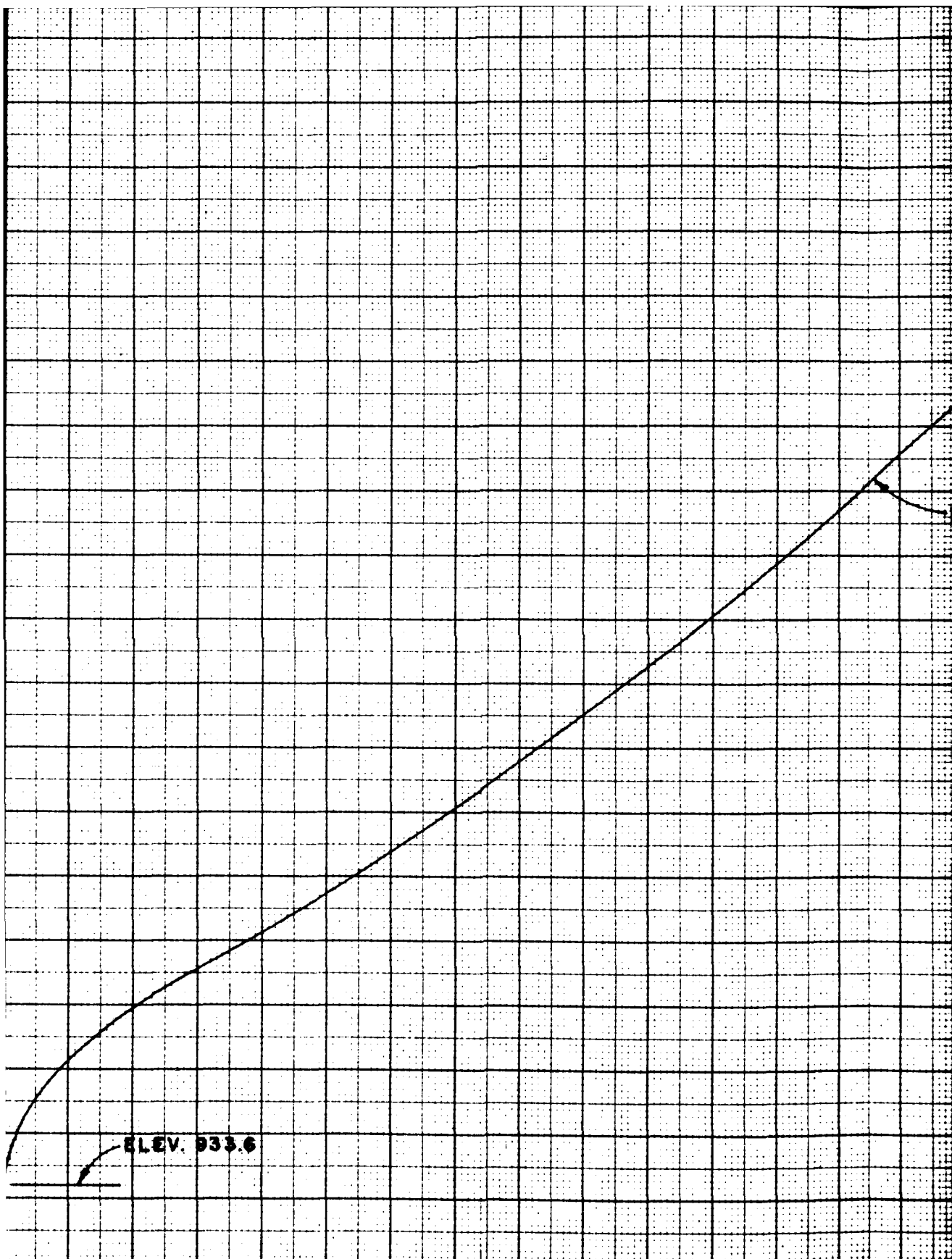
Horner & Shifrin, Inc. Sept. 1979

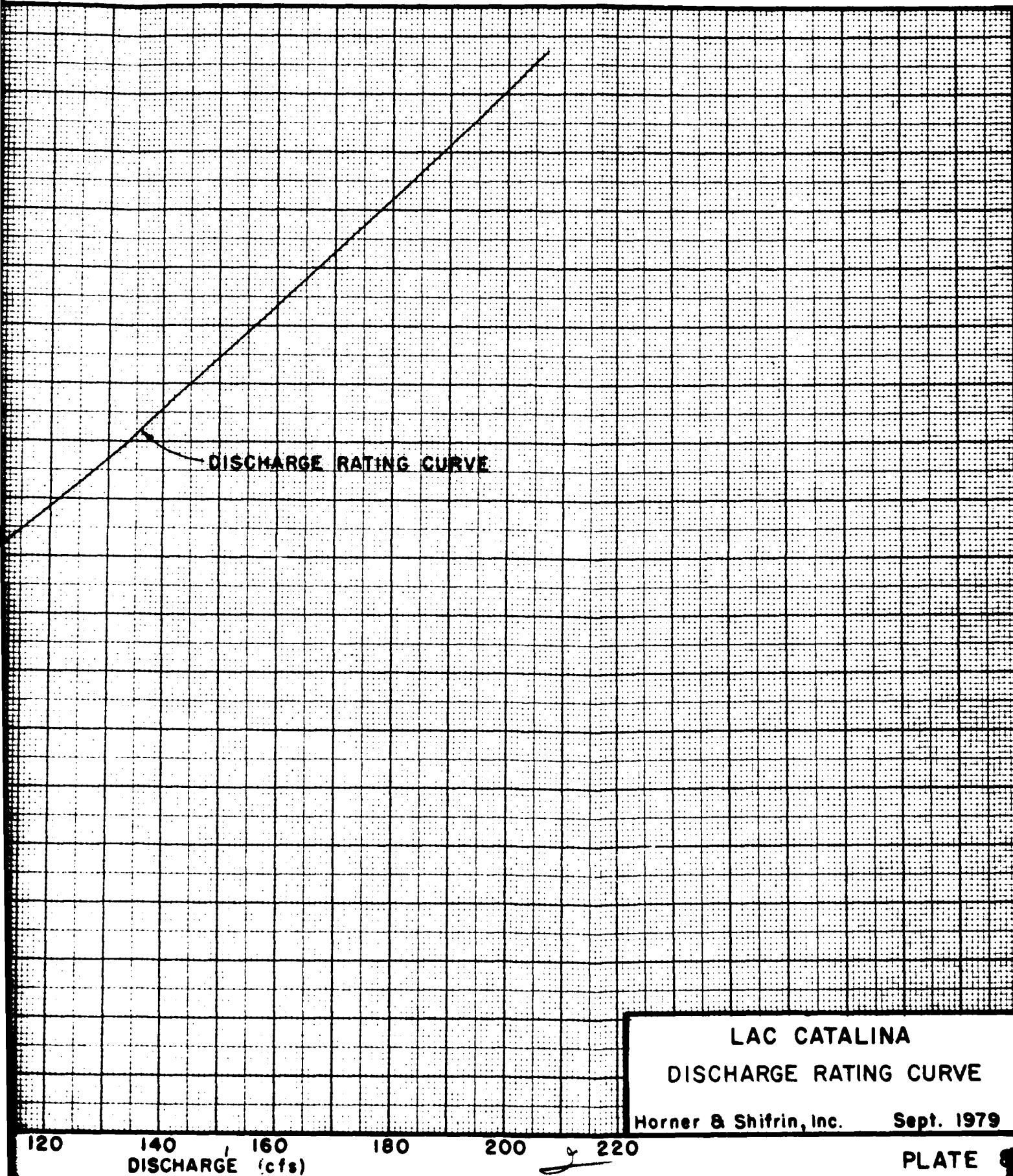
VOLUME (ACRE-FT.) 300
AREA (ACRES) 30

400 2
40

500
50

PLATE 7





APPENDIX A

INSPECTION PHOTOGRAPHS



NO. 1: UPSTREAM FACE OF DAM



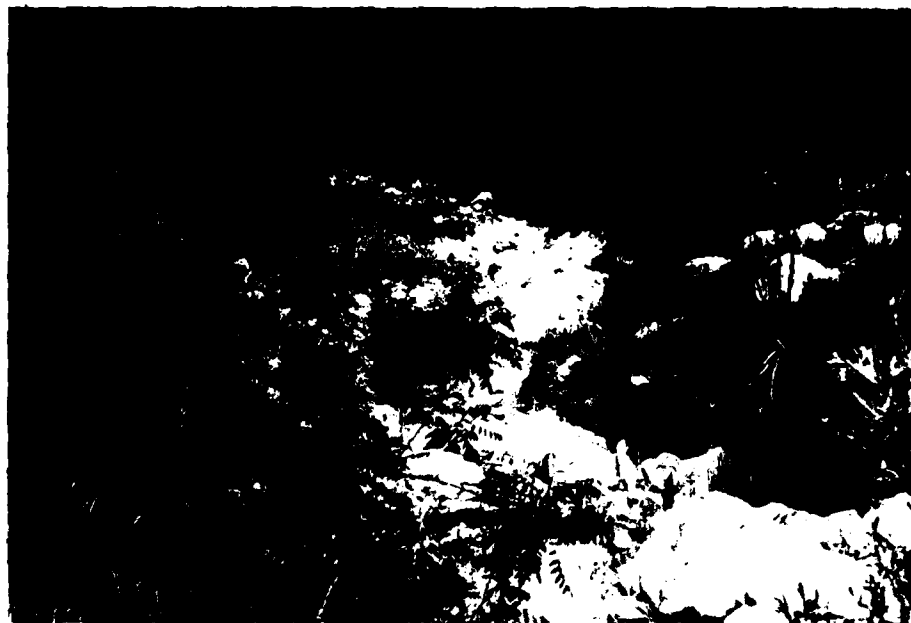
NO. 2: DOWNSTREAM FACE OF DAM



NO. 3: UPSTREAM END OF SPILLWAY PIPE



NO. 4: DOWNSTREAM END OF SPILLWAY PIPE



NO. 5: SPILLWAY DISCHARGE CHANNEL



NO. 6: 6-INCH LAKE DRAWDOWN PIPE



NO. 7: SEEPAGE AT DRAWDOWN PIPE



NO. 8: 8-INCH SANITARY SEWER

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

1. The HEC-1 Dam Safety Version (July 1978, Modified 26 February 1979) program was used to develop inflow and outflow hydrographs and dam overtopping analyses, with hydrologic inputs as follows:

a. Probable maximum precipitation (20 sq. mile, 24-hour value equals 26.5 inches) from Hydrometeorological Report No. 33.

b. Drainage area = 0.09 square miles = 58 acres.

c. SCS parameters:

$$\text{Time of Concentration (Tc)} = \frac{(11.9L)^{0.385}}{H}$$

$$\text{Lag time} = 0.60 \text{ Tc (SCS Method)}$$

$$\text{*Soil type CN} = 74 \text{ (AMC II)}, 88 \text{ (AMC III)}$$

2. Spillway release rate for Lac Catalina was computed utilizing the U.S. Bureau of Public Roads' Inlet and Outlet Control Nomographs for Corrugated Metal Pipe Arch Culverts. The variable parameters for the spillway is as follows:

Entrance Type - Projecting

Length - 50 feet.

Slope - 0.04 (ft./foot)

Discharge Conditions - Free

Entrance head loss coefficient (K) = 0.9

Pipe roughness coefficient (N) = 0.024

*Based on estimated clay content of soil samples obtained on site.

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF LAC CATALINA DAM RATIOS OF PMF ROUTED THROUGH RESERVOIR									
	0	5	10	15	20	25	30	35	40
A1	2.98	1.5	1.0	0.5	0.0	0.0	0.0	0.0	0.0
A2	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
X1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y1	933.6	934.9	935.4	936.5	937.3	937.9	938.1	938.8	940.8
Y4	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9
Y5	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
SE	933.6	933.6	933.6	933.6	933.6	933.6	933.6	933.6	933.6
SD	937.6	937.6	937.6	937.6	937.6	937.6	937.6	937.6	937.6
SL	937.6	937.6	937.6	937.6	937.6	937.6	937.6	937.6	937.6
SV	937.6	937.6	937.6	937.6	937.6	937.6	937.6	937.6	937.6
K	937.6	937.6	937.6	937.6	937.6	937.6	937.6	937.6	937.6

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT
ROUTE HYDROGRAPH TO
END OF NETWORK

33	394.3	933.6	940	550			
34	933.6						
35	937.1	160	280	305	419	477	498
36	937.6	938.2	938.6	938.7	939.8	940.1	941
37	939.9						574
							944

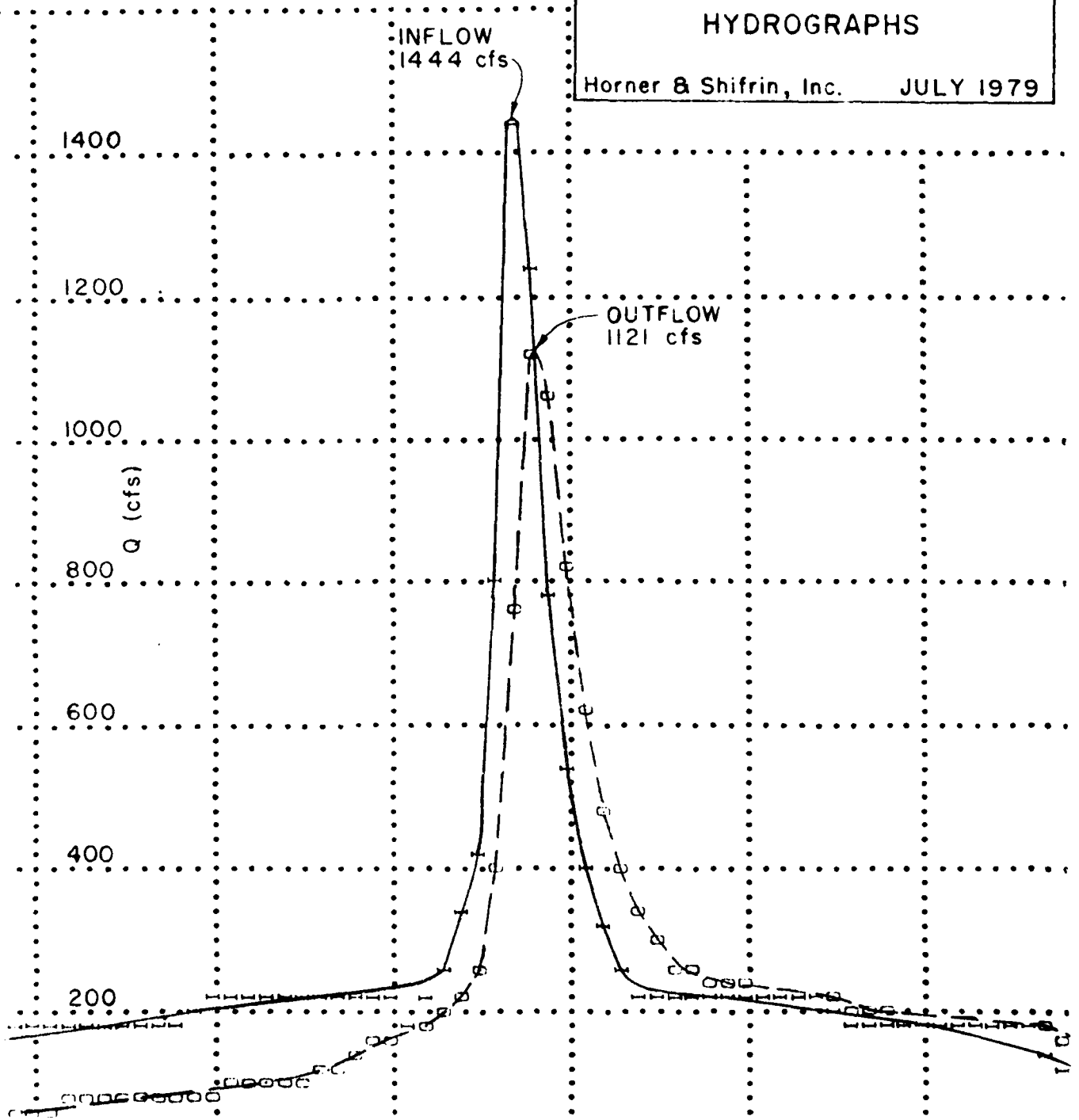
PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS
 RUNOFF HYDROGRAPH AT INFLUX
 POINT HYDROGRAPH TO DAM
 END OF NETWORK

SUMMARY OF DAM SAFETY ANALYSIS

RATIO OF PME	ELEVATION STORAGE OUTFLOW	MAXIMUM RESERVOIR W.S. ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER HOURS	TOP OF DAM SPILLWAY CREST 933.60 71.0. 98.	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.05	934.31	934.97	0.00	75.	10.	0.00	937.60	17.08	0.00
.10	934.97	935.49	0.00	79.	20.	0.00	937.60	17.08	0.00
.15	935.49	935.99	0.00	82.	35.	0.00	937.60	16.17	0.00
.20	935.99	936.44	0.00	86.	51.	0.00	937.60	16.08	0.00
.25	936.44	936.86	0.00	91.	65.	0.00	937.60	16.08	0.00
.30	936.86	937.05	0.05	93.	77.	0.00	937.60	16.08	0.00
.40	937.05	937.20	.05	100.	100.	2.75	937.60	15.92	0.00
.50	937.20	937.20	1.60	105.	242.	5.33	937.60	15.67	0.00
1.00	939.17	939.17	1.57	115.	1153.	5.33	937.60	15.67	0.00

LAC CATALINA PMF INFLOW & OUTFLOW HYDROGRAPHS

Horner & Shifrin, Inc. JULY 1979



TIME (Hr/Min) FROM BEGIN OF RAINFALL

14:13 14:15 14:17 14:19 14:21 14:23 14:25 14:27 14:29 14:31 14:33 14:35 14:37 14:39 14:41 14:43 14:45 14:47 14:49 14:51 14:53 14:55 14:57 14:59 15:01 15:03 15:05 15:07 15:09 15:11 15:13 15:15 15:17 15:19 15:21 15:23 15:25 15:27 15:29 15:31 15:33 15:35 15:37 15:39 15:41 15:43 15:45 15:47 15:49 15:51 15:53 15:55 15:57 15:59 16:01 16:03 16:05 16:07 16:09 16:11 16:13 16:15 16:17 16:19 16:21 16:23 16:25 16:27 16:29 16:31 16:33 16:35 16:37 16:39 16:41 16:43 16:45 16:47 16:49 16:51 16:53 16:55 16:57 16:59 17:01 17:03 17:05 17:07 17:09 17:11 17:13 17:15 17:17 17:19 17:21 17:23 17:25 17:27 17:29 17:31 17:33 17:35 17:37 17:39 17:41 17:43 17:45 17:47 17:49 17:51 17:53 17:55 17:57 17:59 18:01 18:03 18:05 18:07 18:09 18:11 18:13 18:15 18:17 18:19 18:21 18:23 18:25 18:27 18:29 18:31 18:33 18:35 18:37 18:39 18:41 18:43 18:45 18:47 18:49 18:51 18:53 18:55 18:57 18:59 19:01 19:03 19:05 19:07 19:09 19:11 19:13 19:15 19:17 19:19 19:21 19:23 19:25 19:27 19:29 19:31 19:33 19:35 19:37 19:39 19:41 19:43 19:45 19:47 19:49 19:51 19:53 19:55 19:57 19:59 20:01 20:03 20:05 20:07 20:09 20:11 20:13 20:15 20:17 20:19 20:21 20:23 20:25 20:27 20:29 20:31 20:33 20:35 20:37 20:39 20:41 20:43 20:45 20:47 20:49 20:51 20:53 20:55 20:57 20:59 21:01 21:03 21:05 21:07 21:09 21:11 21:13 21:15 21:17 21:19 21:21 21:23 21:25 21:27 21:29 21:31 21:33 21:35 21:37 21:39 21:41 21:43 21:45 21:47 21:49 21:51 21:53 21:55 21:57 21:59 22:01 22:03 22:05 22:07 22:09 22:11 22:13 22:15 22:17 22:19 22:21 22:23 22:25 22:27 22:29 22:31 22:33 22:35 22:37 22:39 22:41 22:43 22:45 22:47 22:49 22:51 22:53 22:55 22:57 22:59 23:01 23:03 23:05 23:07 23:09 23:11 23:13 23:15 23:17 23:19 23:21 23:23 23:25 23:27 23:29 23:31 23:33 23:35 23:37 23:39 23:41 23:43 23:45 23:47 23:49 23:51 23:53 23:55 23:57 23:59 24:01 24:03 24:05 24:07 24:09 24:11 24:13 24:15 24:17 24:19 24:21 24:23 24:25 24:27 24:29 24:31 24:33 24:35 24:37 24:39 24:41 24:43 24:45 24:47 24:49 24:51 24:53 24:55 24:57 24:59 25:01 25:03 25:05 25:07 25:09 25:11 25:13 25:15 25:17 25:19 25:21 25:23 25:25 25:27 25:29 25:31 25:33 25:35 25:37 25:39 25:41 25:43 25:45 25:47 25:49 25:51 25:53 25:55 25:57 25:59 26:01 26:03 26:05 26:07 26:09 26:11 26:13 26:15 26:17 26:19 26:21 26:23 26:25 26:27 26:29 26:31 26:33 26:35 26:37 26:39 26:41 26:43 26:45 26:47 26:49 26:51 26:53 26:55 26:57 26:59 27:01 27:03 27:05 27:07 27:09 27:11 27:13 27:15 27:17 27:19 27:21 27:23 27:25 27:27 27:29 27:31 27:33 27:35 27:37 27:39 27:41 27:43 27:45 27:47 27:49 27:51 27:53 27:55 27:57 27:59 28:01 28:03 28:05 28:07 28:09 28:11 28:13 28:15 28:17 28:19 28:21 28:23 28:25 28:27 28:29 28:31 28:33 28:35 28:37 28:39 28:41 28:43 28:45 28:47 28:49 28:51 28:53 28:55 28:57 28:59 29:01 29:03 29:05 29:07 29:09 29:11 29:13 29:15 29:17 29:19 29:21 29:23 29:25 29:27 29:29 29:31 29:33 29:35 29:37 29:39 29:41 29:43 29:45 29:47 29:49 29:51 29:53 29:55 29:57 29:59 30:01 30:03 30:05 30:07 30:09 30:11 30:13 30:15 30:17 30:19 30:21 30:23 30:25 30:27 30:29 30:31 30:33 30:35 30:37 30:39 30:41 30:43 30:45 30:47 30:49 30:51 30:53 30:55 30:57 30:59 31:01 31:03 31:05 31:07 31:09 31:11 31:13 31:15 31:17 31:19 31:21 31:23 31:25 31:27 31:29 31:31 31:33 31:35 31:37 31:39 31:41 31:43 31:45 31:47 31:49 31:51 31:53 31:55 31:57 31:59 32:01 32:03 32:05 32:07 32:09 32:11 32:13 32:15 32:17 32:19 32:21 32:23 32:25 32:27 32:29 32:31 32:33 32:35 32:37 32:39 32:41 32:43 32:45 32:47 32:49 32:51 32:53 32:55 32:57 32:59 33:01 33:03 33:05 33:07 33:09 33:11 33:13 33:15 33:17 33:19 33:21 33:23 33:25 33:27 33:29 33:31 33:33 33:35 33:37 33:39 33:41 33:43 33:45 33:47 33:49 33:51 33:53 33:55 33:57 33:59 34:01 34:03 34:05 34:07 34:09 34:11 34:13 34:15 34:17 34:19 34:21 34:23 34:25 34:27 34:29 34:31 34:33 34:35 34:37 34:39 34:41 34:43 34:45 34:47 34:49 34:51 34:53 34:55 34:57 34:59 35:01 35:03 35:05 35:07 35:09 35:11 35:13 35:15 35:17 35:19 35:21 35:23 35:25 35:27 35:29 35:31 35:33 35:35 35:37 35:39 35:41 35:43 35:45 35:47 35:49 35:51 35:53 35:55 35:57 35:59 36:01 36:03 36:05 36:07 36:09 36:11 36:13 36:15 36:17 36:19 36:21 36:23 36:25 36:27 36:29 36:31 36:33 36:35 36:37 36:39 36:41 36:43 36:45 36:47 36:49 36:51 36:53 36:55 36:57 36:59 37:01 37:03 37:05 37:07 37:09 37:11 37:13 37:15 37:17 37:19 37:21 37:23 37:25 37:27 37:29 37:31 37:33 37:35 37:37 37:39 37:41 37:43 37:45 37:47 37:49 37:51 37:53 37:55 37:57 37:59 38:01 38:03 38:05 38:07 38:09 38:11 38:13 38:15 38:17 38:19 38:21 38:23 38:25 38:27 38:29 38:31 38:33 38:35 38:37 38:39 38:41 38:43 38:45 38:47 38:49 38:51 38:53 38:55 38:57 38:59 39:01 39:03 39:05 39:07 39:09 39:11 39:13 39:15 39:17 39:19 39:21 39:23 39:25 39:27 39:29 39:31 39:33 39:35 39:37 39:39 39:41 39:43 39:45 39:47 39:49 39:51 39:53 39:55 39:57 39:59 40:01 40:03 40:05 40:07 40:09 40:11 40:13 40:15 40:17 40:19 40:21 40:23 40:25 40:27 40:29 40:31 40:33 40:35 40:37 40:39 40:41 40:43 40:45 40:47 40:49 40:51 40:53 40:55 40:57 40:59 41:01 41:03 41:05 41:07 41:09 41:11 41:13 41:15 41:17 41:19 41:21 41:23 41:25 41:27 41:29 41:31 41:33 41:35 41:37 41:39 41:41 41:43 41:45 41:47 41:49 41:51 41:53 41:55 41:57 41:59 42:01 42:03 42:05 42:07 42:09 42:11 42:13 42:15 42:17 42:19 42:21 42:23 42:25 42:27 42:29 42:31 42:33 42:35 42:37 42:39 42:41 42:43 42:45 42:47 42:49 42:51 42:53 42:55 42:57 42:59 43:01 43:03 43:05 43:07 43:09 43:11 43:13 43:15 43:17 43:19 43:21 43:23 43:25 43:27 43:29 43:31 43:33 43:35 43:37 43:39 43:41 43:43 43:45 43:47 43:49 43:51 43:53 43:55 43:57 43:59 44:01 44:03 44:05 44:07 44:09 44:11 44:13 44:15 44:17 44:19 44:21 44:23 44:25 44:27 44:29 44:31 44:33 44:35 44:37 44:39 44:41 44:43 44:45 44:47 44:49 44:51 44:53 44:55 44:57 44:59 45:01 45:03 45:05 45:07 45:09 45:11 45:13 45:15 45:17 45:19 45:21 45:23 45:25 45:27 45:29 45:31 45:33 45:35 45:37 45:39 45:41 45:43 45:45 45:47 45:49 45:51 45:53 45:55 45:57 45:59 46:01 46:03 46:05 46:07 46:09 46:11 46:13 46:15 46:17 46:19 46:21 46:23 46:25 46:27 46:29 46:31 46:33 46:35 46:37 46:39 46:41 46:43 46:45 46:47 46:49 46:51 46:53 46:55 46:57 46:59 47:01 47:03 47:05 47:07 47:09 47:11 47:13 47:15 47:17 47:19 47:21 47:23 47:25 47:27 47:29 47:31 47:33 47:35 47:37 47:39 47:41 47:43 47:45 47:47 47:49 47:51 47:53 47:55 47:57 47:59 48:01 48:03 48:05 48:07 48:09 48:11 48:13 48:15 48:17 48:19 48:21 48:23 48:25 48:27 48:29 48:31 48:33 48:35 48:37 48:39 48:41 48:43 48:45 48:47 48:49 48:51 48:53 48:55 48:57 48:59 49:01 49:03 49:05 49:07 49:09 49:11 49:13 49:15 49:17 49:19 49:21 49:23 49:25 49:27 49:29 49:31 49:33 49:35 49:37 49:39 49:41 49:43 49:45 49:47 49:49 49:51 49:53 49:55 49:57 49:59 50:01 50:03 50:05 50:07 50:09 50:11 50:13 50:15 50:17 50:19 50:21 50:23 50:25 50:27 50:29 50:31 50:33 50:35 50:37 50:39 50:41 50:43 50:45 50:47 50:49 50:51 50:53 50:55 50:57 50:59 51:01 51:03 51:05 51:07 51:09 51:11 51:13 51:15 51:17 51:19 51:21 51:23 51:25 51:27 51:29 51:31 51:33 51:35 51:37 51:39 51:41 51:43 51:45 51:47 51:49 51:51 51:53 51:55 51:57 51:59 52:01 52:03 52:05 52:07 52:09 52:11 52:13 52:15 52:17 52:19 52:21 52:23 52:25 52:27 52:29 52:31 52:33 52:35 52:37 52:39 52:41 52:43 52:45 52:47 52:49 52:51 52:53 52:55 52:57 52:59 53:01 53:03 53:05 53:07 53:09 53:11 53:13 53:15 53:17 53:19 53:21 53:23 53:25 53:27 53:29 53:31 53:33 53:35 53:37 53:39 53:41 53:43 53:45 53:47 53:49 53:51 53:53 53:55 53:57 53:59 54:01 54:03 54:05 54:07 54:09 54:11 54:13 54:15 54:17 54:19 54:21 54:23 54:25 54:27 54:29 54:31 54:33 54:35 54:37 54:39 54:41 54:43 54:45 54:47 54:49 54:51 54:53 54:55 54:57 54:59 55:01 55:03 55:05 55:07 55:09 55:11 55:13 55:15 55:17 55:19 55:21 55:23 55:25 55:27 55:29 55:31 55:33 55:35 55:37 55:39 55:41 55:43 55:45 55:47 55:49 55:51 55:53 55:55 55:57 55:59 56:01 56:03 56:05 56:07 56:09 56:11 56:13 56:15 56:17 56:19 56:21 56:23 56:25 56:27 56:29 56:31 56:33 56:35 56:37 56:39 56:41 56:43 56:45 56:47 56:49 56:51 56:53 56:55 56:57 56:59 57:01 57:03 57:05 57:07 57:09 57:11 57:13 57:15 57:17 57:19 57:21 57:23 57:25 57:27 57:29 57:31 57:33 57:35 57:37 57:39 57:41 57:43 57:45 57:47 57:49 57:51 57:53 57:55 57:57 57:59 58:01 58:03 58:05 58:07 58:09 58:11 58:13 58:15 58:17 58:19 58:21 58:23 58:25 58:27 58:29 58:31 58:33 58:35 58:37 58:39 58:41 58:43 58:45 58:47 58:49 58:51 58:53 58:55 58:57 58:59 59:01 59:03 59:05 59:07 59:09 59:11 59:13 59:15 59:17 59:19 59:21 59:23 59:25 59:27 59:29 59:31 59:33 59:35 59:37 59:39 59:41 59:43 59:45 59:47 59:49 59:51 59:53 59:55 59:57 59:59 60:01 60:03 60:05 60:07 60:09 60:11 60:13 60:15 60:17 60:19 60:21 60:23 60:25 60:27 60:29 60:31 60:33 60:35 60:37 60:39 60:41 60:43 60:45 60:47 60:49 60:51 60:53 60:55 60:57 60:59 61:01 61:03 61:05 61:07 61:09 61:11 61:13 61:15 61:17 61:19 61:21 61:23 61:25 61:27 61:29 61:31 61:33 61:35 61:37 61:39 61:41 61:43 61:45 61:47 61:49 61:51 61:53 61:55 61:57 61:59 62:01 62:03 62:05 62:07 62:09 62:11 62:13 62:15 62:17 62:19 62:21 62:23 62:25 62:27 62:29 62:31 62:33 62:35 62:37 62:39 62:41 62:43 62:45 62:47 62:49 62:51 62:53 62:55 62:57 62:59 63:01 63:03 63:05 63:07 63:09 63:11 63:13 63:15 63:17 63:19 63:21 63:23 63:25 63:27 63:29 63:31 63:33 63:35 63:37 63:39 63:41 63:43 63:45 63:47 63:49 63:51 63:53 63:55 63:57 63:59 64:01 64:03 64:05 64:07 64:09 64:11 64:13 64:15 64:17 64:19 64:21 64:23 64:25 64:27 64:29 64:31 64:33 64:35 64:37 64:39 64:41 64:43 64:45 64:47 64:49 64:51 64:53 64:55 64:57 64:59 65:01 65:03 65:05 65:07 65:09 65:11 65:13 65:15 65:17 65:19 65:21 65:23 65:25 65:27 65:29 65:31 65:33 65:35 65:37 65:39 65:41 65:43 65:45 65:47 65:49 65:51 65:53 65:55 65:57 65:59 66:01 66:03 66:05 66:07 66:09 66:11 66:13 66:15 66:17 66:19 66:21 66:23 66:25 66:27 66:29 66:31 66:33 66:35 66:37 66:39 66:41 66:43 66:45 66:47 66:49 66:51 66:53 66:55 66:57 66:59 67:01 67:03 67:05 67:07 67:09 67:11 67:13 67:15 67:17 67:19 67:21 67:23 67:25 67:27 67:29 67:31 67:33 67:35 67:37 67:39 67:41 67:43 67:45 67:47 67:49 67:51 67:53 67:55 67:57 67:59 68:01 68:03 68:05 68:07 68:09 68:11 68:13 68:15 68:17 68:19 68:21 68:23 68:25 68:27 68:29 68:31 68:33 68:35 68:37 68:39 68:41 68:43 68:45 68:47 68:49 68:51 68:53 68:55 68:57 68:59 69:01 69:03 69:05 69:07 69:09 69:11 69:13 69:15 69:17 69:19 69:21 69:23 69:25 69:27 69:29 69:31 69:33 69:35 69:37 69:39 69:41 69:43 69:45 69:47 69:49 69:51 69:53 69:55 69:57 69:59 70:01 70:03 70:05 70:07 70:09 70:11 70:13 70:15 70:17 70:19 70:21 70:23 70:25 70:27 70:29 70:31 70:33 70:35 70:37 70:39 70:41 70:43 70:45 70:47 70:49 70:51 70:53 70:55 70:57 70:59 71:01 71:03 71:05 71:07 71:09 71:11 71:13 71:15 71:17 71:19 71:21 71:23 71:25 71:27 71:29 71:31 71:33 71:35 71:37 71:39 71:41 71:43 71:45 71:47 71:49 71:51 71:53 71:55 71:57 71:59 72:01 72:03 72:05 72:07 72:09 72:11 72:13 72:15 72:17 72:19 72:21 72:23 72:25 72:27 72:29 72:31 72:33 72:35 72:37 72:39 72:41 72:43 72:45 72:47 72:49 72:51 72:53 72:55 72:57 72:59 73:01 73:03 73:05 73:07 73:09 73:11 73:13 73:15 73:17 73:19 73:21 73:23 73:25 73:27 73:29 73:31 73:33 73:35 73:37 73:39 73:41 73:43 73:45 73:47 73:49 73:51 73:53 73:55 73:57 73:59 74:01 74:03 74:05 74:07 74:09 74:11 74:13 74:15 74:17 74:19 74:21 74:23 74:25 74:27 74:29 74:31 74:33 74:35 74:37 74:39 74:41 74:43 74:45 74:47 74:49 74:51 74:53 74:55 74:57 74:59 75:01 75:03 75:05 75:07 75:09 75:11 75:13 75:15 75:17 75:19 75:21 75:23 75:25 75:27 75:29 75:31 75:33 75:35 75:37 75:39 75:41 75:43 75:45 75:47 75:49 75:51 75:53 75:55 75:57 75:59 76:01 76:03 76:05 76:07 76:09 76:11 76:13 76:15 76:17 76:19 76:21 76:23 76:25 76:27 76:29 76:31 76:33 76:35 76:37 76:39 76:41 76:43 76:45 76:47 76:

9330

20

40

60

80

100

120

140

DISCHARGE

END

DATE
FILMED

11-81

DTIC