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ARMY ENGINEER DISTRICT ST LOUIS MO
NATIONAL DAM SAFETY PROGRAM. CHAIN OF LAKES DAMS (MO 30347, MO --ETC(U)
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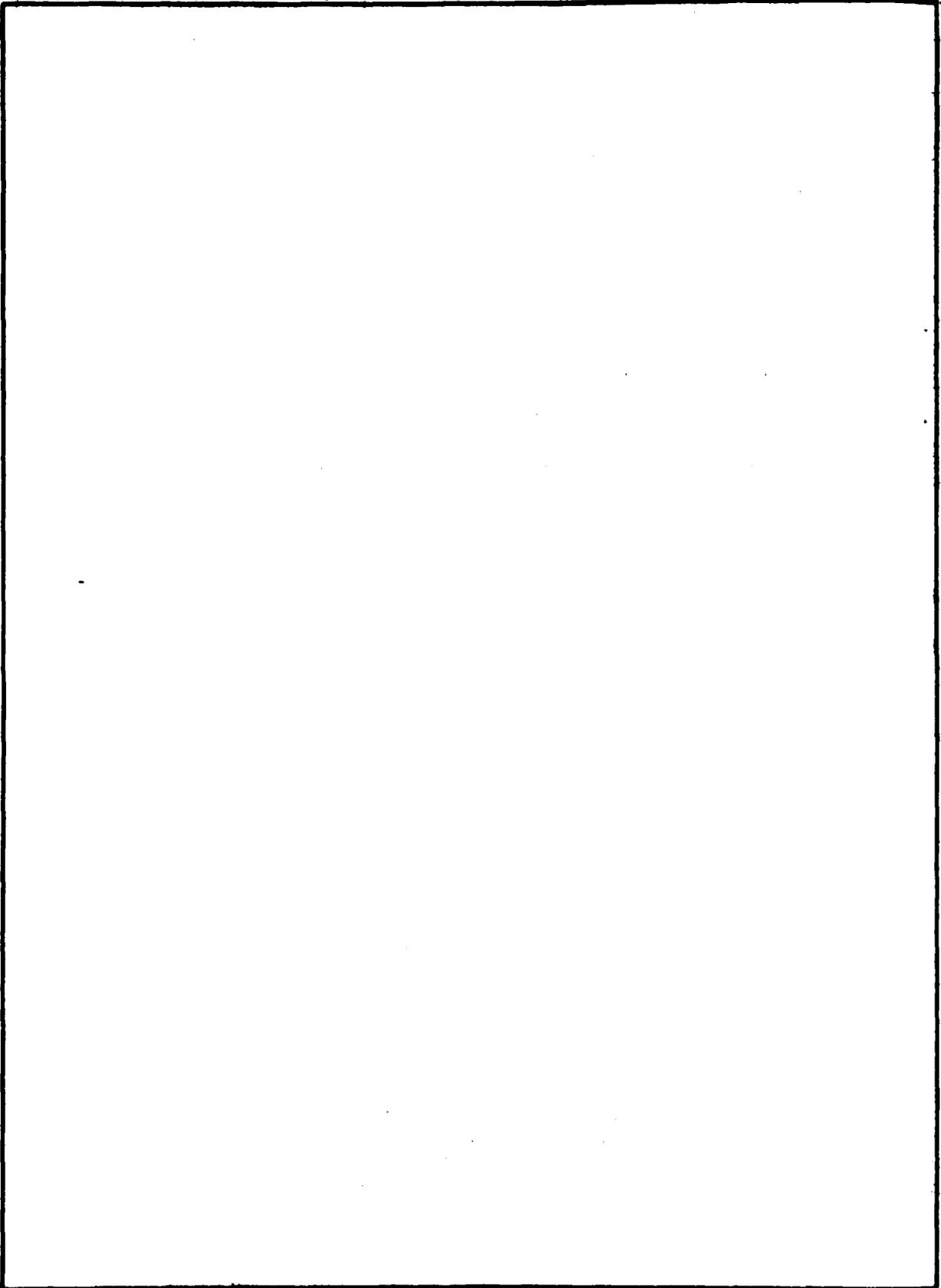
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ST. FRANCIS RIVER BASIN

CHAIN OF LAKES DAMS
WAYNE COUNTY, MISSOURI

MISSOURI INVENTORY NOS. 30347
30348
31032

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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PREPARED BY: ST. LOUIS DISTRICT CORPS OF ENGINEERS
FOR: GOVERNOR OF MISSOURI

MAY 1978

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Phase I Report
National Dam Safety Program

NAME: Chain of Lakes Dams (also known as Shy Dams and/or Seven (7) Lakes Dams)

LOCATION: Wayne County, Missouri

STREAM: Goose Creek

DATE OF INSPECTION: 4 April 1978

Dams No. 1 (Mo30347), 2 (Mo30348), and 3 (Mo31032) at the "Chain of Lakes" were inspected using the "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed by the Chief of Engineers, U.S. Army, Washington D.C., with the help of Federal and State agencies, professional engineering organizations, and private engineers. The resulting guidelines are considered to represent a consensus of the engineering profession.

Based on the criteria in the guidelines, the dams acting as a system are in the high hazard potential classification, which means that loss of more than a few lives and appreciable property loss could occur in the event of failure of the dams. Over 30 structures would be subjected to flooding with possible damage and /or destruction and possible loss of life. The dams are in the small size classification because they are less than 40 feet high and impound less than 1000 acre-feet of water.

Our evaluation of the spillways' size indicates that they do not meet the criteria in the guidelines. The spillways of dams No. 2 and 3 are of inadequate size to pass the one percent chance flood (100-year flood) without overtopping. The spillway of dam No. 1 is just adequate to pass the one percent chance flood; but if either dam No. 2 or No. 3 failed due to overtopping, dam No. 1 would overtop also. The one percent chance flood is a flood that would have a one percent chance of being exceeded in any given year. The guidelines recommend dams of this size and hazard classification have spillways capable of passing from one-half to all of the Probable Maximum Flood, an event with greater flow and a less frequent chance of occurrence than a one percent chance flood.

The inspection team observed trees and bushes growing in the three dams inspected, particularly dam No. 3. These root systems are a potential seepage hazard. Localized areas of the embankment slopes are exceptionally steep. Steady seepage conditions exist through dam No. 1 and a localized seepage area was found downstream of dam No. 2. The pool of dam No. 2 was on the downstream slope of dam No. 3 and seepage could not be evaluated.

Cont'd

The three spillways do not appear sufficiently resistant to prevent embankment erosion at high flows for an indefinite time. Stilling basins are needed below each spillway. Seepage and stability analyses are not on record as recommended in the guidelines.

We recommend action be taken by the owner to correct the deficiencies listed herein in the near future. Corrective works should be in accordance with analyses and design performed by an engineer experienced in the design of dams. These conclusions were reached by the undersigned inspection team members.

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THOMAS F. WOLFF
Soils Engineer

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Hydraulic Engineer

Gregory L. Hempen
GREGORY L. HEMPEN
Geologist

SUBMITTED BY: *[Signature]*
Chief, Engineering Division

15 Jul 78
Date

APPROVED BY: *[Signature]*
Colonel, CE, District Engineer

7 July 78
Date



OVERVIEW OF LAKES No. 1 , 2 , and 3

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
CHAIN OF LAKES DAMS

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PHOTOGRAPHS

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
CHAIN OF LAKES DAMS ID NOS. 30347, 30348, 31032

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 St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of the Chain of Lakes Dams be made.

b. Purpose of Inspection: The purpose of the inspection was to make an assessment of the general condition of the dams with respect to safety, based upon available data and visual inspection, in order to determine if the dams pose hazards to human life or property.

c. Evaluation Guidelines: The inspection was accomplished using the "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed by the Chief of Engineers, U.S. Army, Washington D.C., with the help of Federal and State agencies, professional engineering organizations, and private engineers. The resulting guidelines are considered to represent a consensus of the engineering profession.

1.2 DESCRIPTION OF PROJECT.

a. Description of Dams and Appurtenances: These are earthfill dams. The appurtenant structures at each dam consist of a spillway. In addition, Dam No. 2 is reported to have an 8-inch diameter pipe through it, capped underwater on the upstream side.

b. Location: Section 20 and 29, Township 30 North, Range 4 East

c. Size Classification: Small

d. Hazard Classification: High

e. Ownership: Mr. Paul Shy
Route 3
DeSoto, Missouri 63020

f. Purpose of Dams: Recreation - Resort Area

g. Design and Construction History: The three (3) dams were reportedly constructed 34 years ago (1944+) by the present owner. The dams were reportedly constructed using borrow material from the lake area placed in lifts and compacted by tracking with a rubber-tired scraper. The dams reportedly have a clay cutoff trench to rock about eight feet wide.

h. Normal Operational Procedure: No operating records exist. At all three (3) dams, outflow passes over uncontrolled spillways.

1.3 PERTINENT DATA - Dam #1 (Inventory No. 30347)

a. Drainage Areas: 1326 Acres

b. Discharge at Damsite: Not known

Maximum known flood at damsite - 1 to 2 feet depth over spillway reported

Spillway capacity at maximum pool elevation - 1940 cfs @ el 646 ft. msl

c. Elevation (ft. above MSL):

Top of dam - 646.0

Flood control pool - 646.0

Recreation pool - 640.5

Streambed - 615+

Maximum tailwater - Not known

d. Reservoir:

Length of maximum pool - Approximately 2000 feet

Length of recreation pool - Approximately 1600 feet

e. Storage (acre-feet):

Recreation pool - 183

Flood control pool - 144

Design surcharge - 0

Top of dam - 327

f. Reservoir Storage (acres):

Top of dam - 32.7

Maximum pool - 32.7

Flood-control pool - 32.7

Recreation pool - 22.3

Spillway crest - 22.3

g. Dam:

Type - Earth fill

Length - 569 feet

Height - 30+ feet

Top width - 8 feet

Side slopes - Varies, 1 vertical on 2.6 horizontal at maximum downstream section

Zoning - Not known

Impervious core - Not known

Cutoff - Reportedly has 8 ft. wide clay cutoff

Grout curtain - Reportedly none

h. Diversion and Regulating Tunnel: None

i. Spillway:

Type - Earth/rock/concrete

Length of weir - 40 feet

Crest elevation - 640.6

Gates - None

j. Regulating Outlets: None

PERTINENT DATA - Dam #2 (Inventory No. 30348)

a. Drainage Areas: 558 Acres

b. Discharge at Damsite: Unknown

Maximum known flood at damsite - Unknown - 1 to 2 feet
depth over spillway reported

Spillway capacity at maximum pool elevation - 659 cfs
@ el 669 ft. msl

c. Elevation (ft. above MSL):

Top dam - 670+ feet

Flood control pool - 669

Recreation pool - 665.5

Streambed - 645+ feet

Maximum tailwater - Not known

d. Reservoir:

Length of maximum pool - 1100 ft.

Length of recreation pool - 1100 ft.

e. Storage (acre-feet):

Recreation pool - 82

Flood control pool - 43

Design surcharge - 13

Top of dam - 138

f. Reservoir Storage (acres):

Top of dam - 18

Maximum pool - 17

Flood-control pool - 17

Recreation pool - 12

Spillway crest - 12

g. Dam:

Type - Earth fill

Length - 920 feet

Height - 24+ feet

Top width - 9 feet

Side slopes - Varies, 1 vertical on 3 horizontal at maximum downstream section

Zoning - Not known

Impervious core - Not known

Cutoff - Reportedly has 8 ft. wide clay cutoff

Grout curtain - Reportedly none

h. Diversion and Regulating Tunnel: None

i. Spillway:

Type - Earth/rock/concrete

Length of weir - 35 feet

Crest elevation - 665.5

Gates - None

j. Regulating Outlets: None

PERTINENT DATA - Dam #3 (Inventory No. 31032)

a. Drainage Areas: 525 Acres

b. Discharge at Damsite:

Maximum known flood at damsite - Unknown - 1 to 2 ft. depth over spillway reported

Spillway capacity at maximum pool elevation - 581 cfs @ el 680 ft msl

c. Elevation (ft. above MSL):

Top dam - 682+ feet

Flood control pool - 680.0

Recreation pool - 677.5

Streambed - Unknown - Pool level of No. 2 was on downstream slope of dam No. 3

Maximum tailwater - Unknown

d. Reservoir:

Length of maximum pool - 1300 feet

Length of recreation pool - 1100 feet

e. Storage (acre-feet):

Recreation pool - 50

Flood control pool - 19

Design surcharge - 24

Top of dam - 93

f. Reservoir Storage (acres):

Top dam - 14

Maximum pool - 12

Flood-control pool - 12

Recreation pool - 10

Spillway crest - 10

g. Dam:

Type - Earth fill

Length - 650+ feet

Height - 20+ feet

Top width - 10 feet

Side slopes - Varies, 1 vertical on 1.4 horizontal at maximum downstream section

Zoning - Not known

Impervious core - Not known

Cutoff - Reportedly has 8 ft. wide clay cutoff

Grout curtain - Reportedly none

h. Diversion and Regulating Tunnel: None

i. Spillway:

Type - Earth/rock/concrete

Length of weir - 45

Crest elevation - 677.5

Gates - None

j. Regulating Outlets: None

Section 2 - Engineering Data

2.1 DESIGN. No design drawings or computations exist.

2.2 CONSTRUCTION. The three dams were reportedly constructed 34 years ago (1944+) by the present owner. The dams were reportedly constructed using borrow material from the lake area placed in lifts and compacted by tracking with a rubber-tired scraper. The dams reportedly have a clay cutoff trench to rock about eight feet wide.

2.3 OPERATION. No operating records exist. At all three dams, outflow passes over uncontrolled spillways.

2.4 EVALUATION.

a. Availability: The only available engineering data is the personal recollections of the owner.

b. Adequacy: The field surveys and visual inspections presented herein are considered adequate to support the conclusions of this report.

c. Validity: Not applicable.

Section 3 - Visual Inspection

3.1 FINDINGS.

a. General: The owner accompanied the inspection team. For purposes of discussion herein, the downstream-most lake is referred to as No. 1, the next upstream lake is No. 2, and the next, No. 3. A fourth lake, also known as Michael's Lake and upstream of No. 3, was found to be less than 25 feet high and to impound less than 50 acre-feet of water and does not fall under the inspection program. At least three additional small dams on the property form lakes or ponds which likewise are too small to require inspection under the program.

b. Project Geology: Field investigations indicated bedrock at the left abutment (northwestern portion) of the No. 1 (lowest) dam, EL 630-660 feet, is a tan to light brown, fine to medium grained, massively bedded, moderately hard, calcareous dolomite with localized calcite. This dolomite exposure of Upper Cambrian Age weathers to a gray to black, arenaceous textured dolomite which ultimately degrades to a red clayey silt. This outcrop indicates that this dolomite is the Eminence or Potosi formation of the Cambrian System. Both of these formations are bounded above and below by dolomite formations. No other outcrops were observed at the project.

One small spring was noted along the eastern shore of No. 2 lake. Field evidence and information from the owner reveal that the three larger lakes inspected are supplemented by spring flow directly into the lakes. No springs were found which apparently remove water from any of these lakes.

c. Dams: No detrimental settlement, cracking, or sinkholes were observed in or near the earth embankments.

Embankment cross-sections at the maximum height section for each dam are shown on Plates 2 through 4. In a few areas, the embankment slopes are considerably steeper than the section shown. One animal burrow was noted near the crown of dam No. 2. No burrows were noted below pool level at any of the dams but some could be present and masked by vegetation.

All three dams have brush and scattered trees growing on them and dam No. 3, in particular, has a dense covering of brush preventing detailed inspection. Most of the trees at all three dams are less than eight inches in diameter. These root systems constitute a potential seepage hazard. The vegetation also provides animal habitat which increases the likelihood of animal burrows.

Based on surface observations, the dams are composed of reddish brown, very sandy, gravelly clay.

Some riprap exists on the upstream slopes underwater but no riprap was found above the water line at any of the dams.

Marshy areas with standing water were observed downstream of dams No. 1 and No. 2. Since lake No. 2 covers the toe of dam No. 3, the dam toe could not be observed. The lower portion of the embankment of dam No. 1 was saturated, indicating a steady seepage condition exists; but only a "trickle" flow was observed. A clear running seepage area with an estimated flow of less than 20 gallons per minute and covering an area approximately 100 feet square was found at the toe of dam No. 2 near the left abutment. Ground in this area is soft and spongy due to the upward force of the seeping water.

Some erosion, apparently from wave action, was noted in unvegetated areas of the upstream crown, particularly at dam No. 2. Gully erosion was observed at the downstream left abutment of dam No. 1.

d. Appurtenant Structures: Appurtenant structures at each dam consist of a spillway. In addition, dam No. 2 is reported to have an 8-inch diameter pipe through it, capped underwater on the upstream side.

The spillway at dam No. 1 is approximately 40 feet long by 5.4 feet high with a concrete bottom and mortared stone sidewalls. A portion of the left (facing downstream) side of the spillway floor and underlying earth is missing (see photo 4). This damage is reportedly the result of a dynamite blast. About 100 feet downstream of the spillway is a broken concrete apron over which water flows (see photo 3). At both locations, water flows over exposed embankment or foundation material.

The spillway of dam No. 2 is approximately 35 feet long and 3.5 feet high, and is constructed of concrete and stone (see photo 8). In some areas, the sandy, gravelly clay embankment is exposed, large brush and/or small trees are growing in the spillway.

The spillway of dam No. 3 is a near-vertical formed concrete spillway 45 feet long and 2.5 feet high with a thin, horizontal concrete apron (see photo 14). Part of the apron and underlying embankment have eroded away. Some water is getting through cracks in the concrete apron and running under the concrete (see photo 15). The embankment is exposed to lake No. 2 in the outlet channel (see photo 16).

e. Reservoir Area: No pertinent problems were noted in any of the reservoir areas.

f. Downstream Channels: Downstream channels of dams No. 1 and 2 have some trees, logs, and debris in them. Since lake No. 2 extends to dam No. 3, that dam has no downstream channel.

3.2 EVALUATION. Trees and bushes on the embankments, insufficient erosion protection on the upstream faces of the embankments, the lack of stilling basins, and insufficient erosion protection in the spillways are all serious deficiencies which should be corrected. Soft, spongy ground conditions due to seepage at dams No. 1 and No. 2 could lead to instability of the embankment if uncorrected. The seepage in itself need not be stopped but the resulting upward seepage forces should be counterbalanced. A similar condition likely exists underwater, downstream of dam No. 3. Seepage control measures should be based upon analysis of the stability and seepage conditions by a professional engineer experienced in the design and construction of dams.

Section 4 - Operational Procedures

4.1 PROCEDURES. Operational procedures are essentially nonexistent since the dams have uncontrolled spillways and water passes freely over the spillways.

4.2 MAINTENANCE OF DAM. Little maintenance is apparent as evidenced by the vegetative cover, particularly on dam No. 3. the missing area of the spillway concrete on dam No. 1, reportedly dynamited a year ago, has not been repaired. Brush and small trees are growing through and near the spillways, particularly at dam No. 3.

4.3 MAINTENANCE OF OPERATING FACILITIES. Not applicable.

4.4 WARNING SYSTEM. No warning system is known to exist.

4.5 EVALUATION. Additional maintenance in the form of repairing spillways and clearing and mowing the embankments is recommended.

Section 5 - Hydraulic/Hydrologic

5.1 EVALUATION OF FEATURES

a. Design Data: No design data were made available to the inspection team. All releases are non-regulated, with the exception of a reported 8-inch diameter pipe through dam No. 2. This pipe is capped below the water surface in Lake No. 2.

b. Experience Data: All of the pertinent data furnished in this report were derived from U.S. Geological Survey 7½ minute quadrangle sheets or of measurements and surveys made during the inspection.

c. Visual Observations: None of the three dams inspected in the "Chain of Lakes" appear to be in immediate danger of failing, but the following deficiencies were noted:

(1) No stilling basins are present and as a result, significant scour holes exist below all three dams. See Photos 3, 8, 16, and 17.

(2) Portions of the masonry spillway side walls downstream of the crest have failed at all dams and erosion is occurring. See Photos 1, 4, 8, 15, and 16.

(3) Erosion on the upstream portion of dam No. 2 was noted in at least two locations. No protection exists on any upstream embankments.

(4) Trees and bushes are growing on all dam embankments.

(5) A section of the downstream spillway nappe of dam No. 1 is missing. The owner reported this was the result of vandalism. See Photos No. 2 and 4.

(6) The exit channel below dam No. 2 cuts across the downstream toe of the embankment resulting in erosion. See Photo No. 9.

d. Overtopping Potential: Portions of dams No. 2 and 3 would be overtopped between ½ and 2 feet if the 100-year frequency flood occurred. While the duration of flow over the embankments would be relatively short, the embankment's resistance to erosive attack of this magnitude is unreliable and, therefore, either or both dams could fail. Dam No. 1's spillway has just the capacity to pass the 100-year frequency flood without overtopping the dam, but if either or both of the upstream dams failed, dam No. 1 would overtop also. All three dams were, therefore, analyzed using the Probable Maximum Flood as the design storm for the reason stated above and the proximity of houses in the town of Des Arc located below dam No. 1. Routing the PMF through the three spillways reveals all three dams

would be overtopped for approximately four to six hours. This duration and the depth of flow over the dams greatly increases the potential for dam No. 1 to fail. A failure of dam No. 1 would probably result in several homes in the Goose Creek flood plain being destroyed with possible loss of life and significant flooding of structures located in the Black Creek and Big Creek flood plains within the town of Des Arc (See PLATE 1). No effective warning system could be implemented because of the proximity of the town to the dam and the lack of residential development near the dams.

Section 6 - Structural Stability

6.1 EVALUATION OF STRUCTURAL STABILITY.

a. Visual Observations: Visual observations of the dams and spillway are discussed and evaluated in Section 3 and 5. The dams have no other appurtenant structures.

b. Design and Construction Data: As discussed in Section 2, no significant design data are available. No stability analyses or seepage analyses have been performed. Construction data is based on the personal recollections of the owner, who was also the builder.

c. Operating Records: No operating records were available.

d. Post-Construction Changes: According to the owner, no post-construction changes have occurred.

e. Seismic Stability: The Chain of Lakes dams are located in seismic zone 2, for which the recommended guidelines for inspection assign a "moderate" damage probability. Since neither original design analyses nor strengths of embankment or foundation materials are available, an accurate seismic analysis cannot be made.

Section 7 - Assessment/Remedial Measures

7.1 DAM ASSESSMENT.

a. Safety: Several items are deficient which should be corrected. No erosion protection exists on upstream slopes of the dams. Spillways and exit channels are not sufficiently protected against erosion. Spillway walls do not extend to top of dam embankments. Spillway walls and invert have deteriorated. No stilling basins are present and scour holes exist below each spillway. Spillway capacities and/or height of dams are insufficient to pass design floods without overtopping dams. Trees and bushes on the embankments provide a potential seepage hazard and animal habitat.

b. Adequacy of Information: The statements and recommendations in this report are based on visual observations and verbal discussions. Seepage and stability analyses are not on record as prescribed in the recommended guidelines. The downstream embankment toe of dam No. 3 is covered by Lake No. 2 and an assessment of seepage conditions could not be made.

c. Urgency: We recommend the remedial measures listed in Section 7.2 be accomplished in the near future.

d. Necessity for Phase II: No Phase II inspection is recommended. Action should begin on the remedial actions discussed in this report.

7.2 REMEDIAL MEASURES.

The following remedial measures are recommended:

a. Remove trees and bushes; however, this should not be done on the upstream slopes until riprap placement can follow immediately thereafter.

b. Fill any animal burrows found during clearing.

c. Establish and maintain a grass cover on the embankment.

d. Provide adequately sized, erosion-resistant spillways, stilling basins, and exit channels. Spillways should be designed and constructed to pass the peak outflow of the Probable Maximum Flood with adequate freeboard, or the present spillway capacities could be maintained and the top of the dams raised to contain the PMF with adequate freeboard.

e. Realign the exit channel below dam No. 2 to direct flow away from the toe of the embankment.

f. A stability and seepage analysis of the dams should be performed by a professional engineer experienced in the design and construction of dams. These analyses should provide a design of seepage control works and other remedial measures related to embankment stability and erosion protection.

g. A detailed inspection of the dams and spillways should be made every two to five years by a professional engineer experienced in the design and construction of dams.

h. The residents near Des Arc should be advised of the flooding potential from overtopping or failure of the Chain of Lakes Dams.

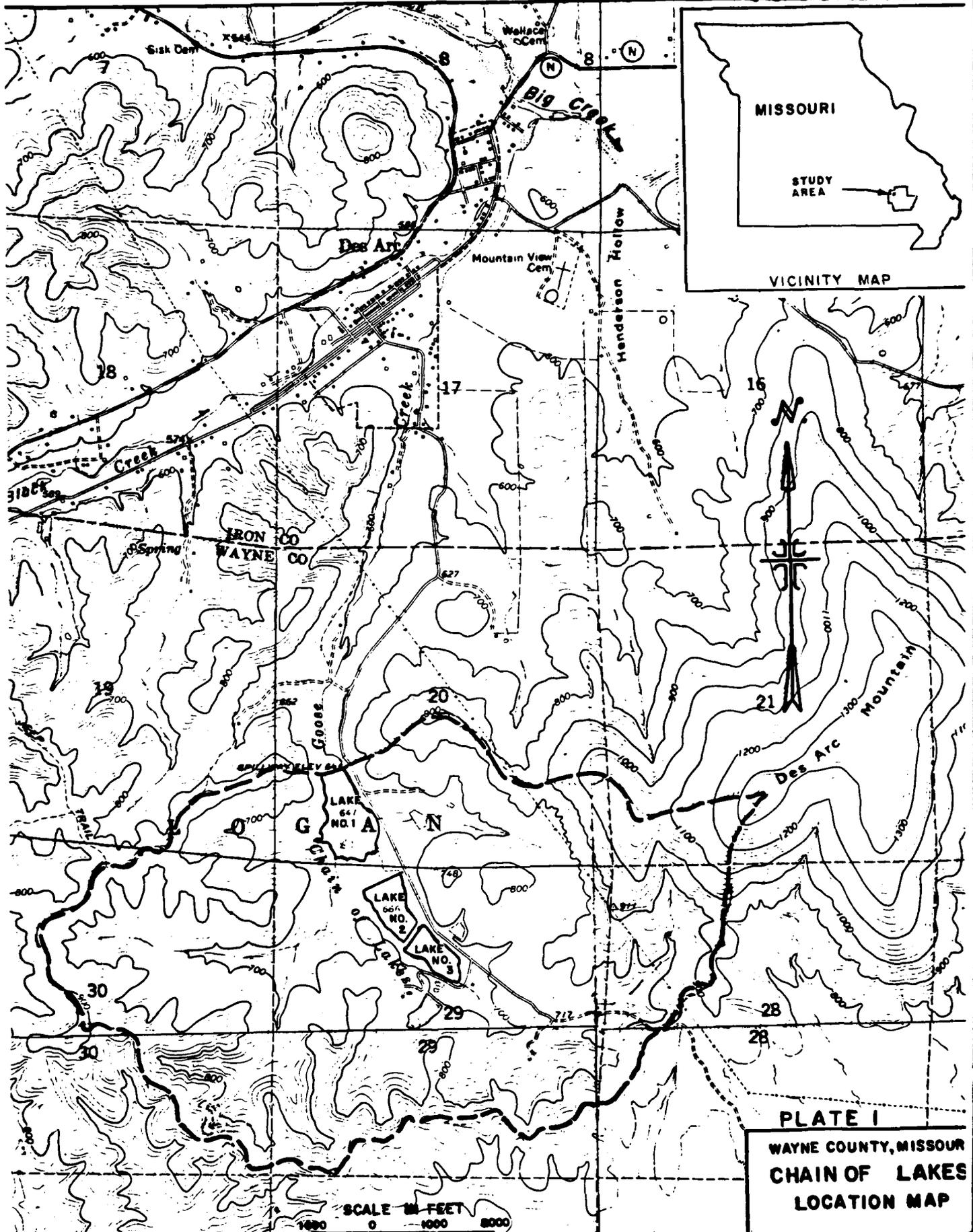


PLATE I
WAYNE COUNTY, MISSOURI
CHAIN OF LAKES
LOCATION MAP

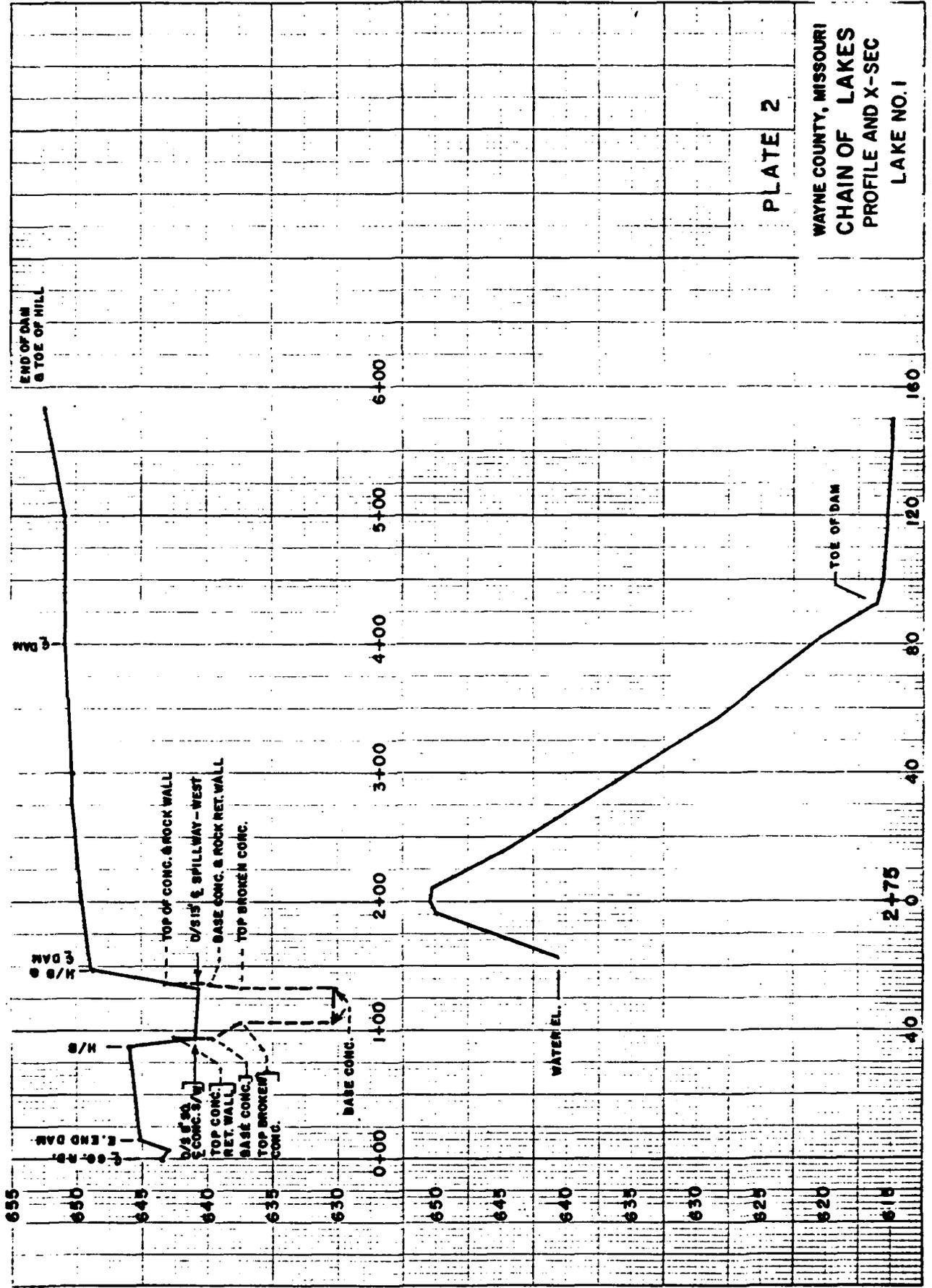


PLATE 2

WAYNE COUNTY, MISSOURI
 CHAIN OF LAKES
 PROFILE AND X-SEC
 LAKE NO. 1

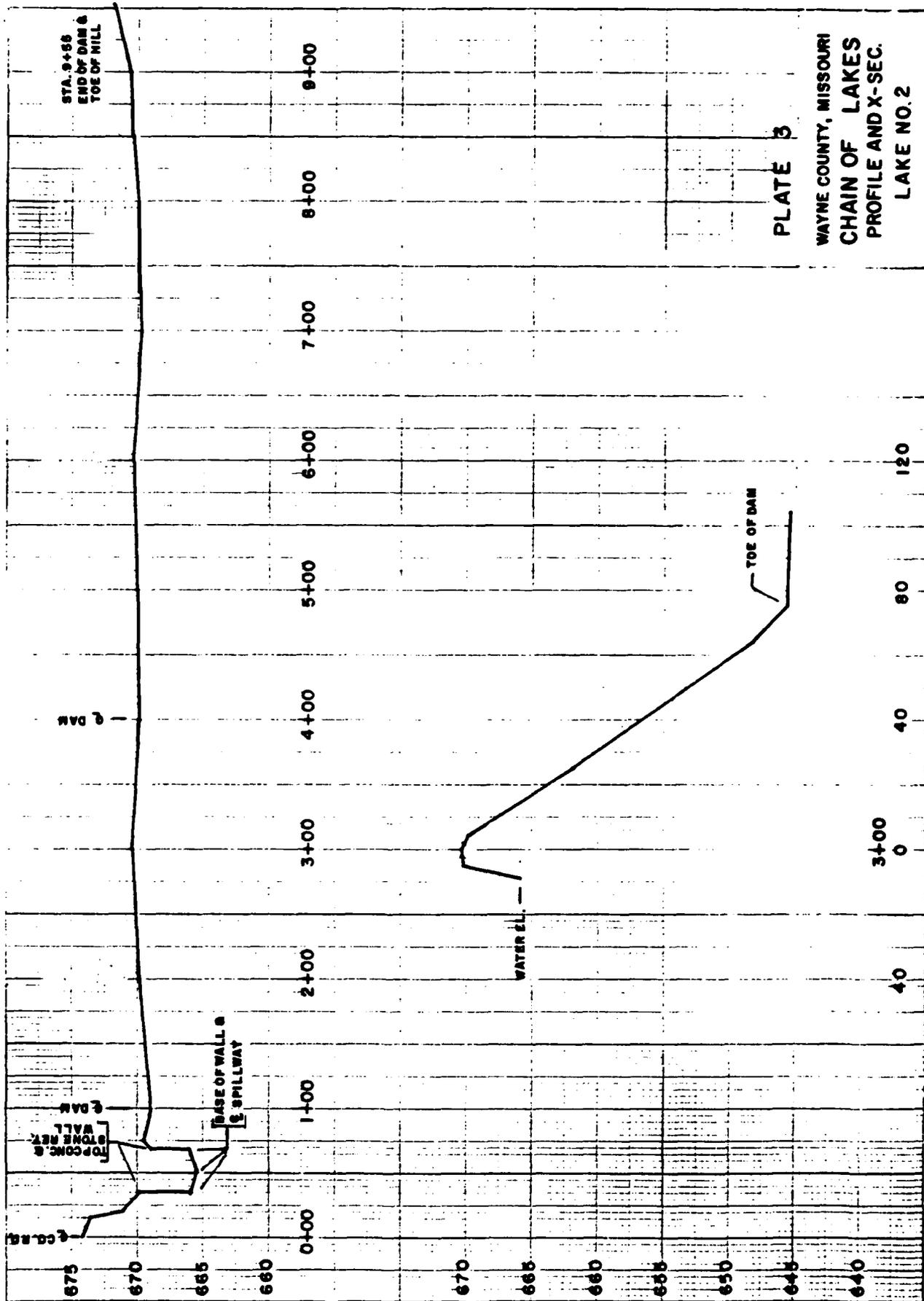


PLATE 3

WAYNE COUNTY, MISSOURI
 CHAIN OF LAKES
 PROFILE AND X-SEC.
 LAKE NO. 2

120

80

40

3+00
0

40

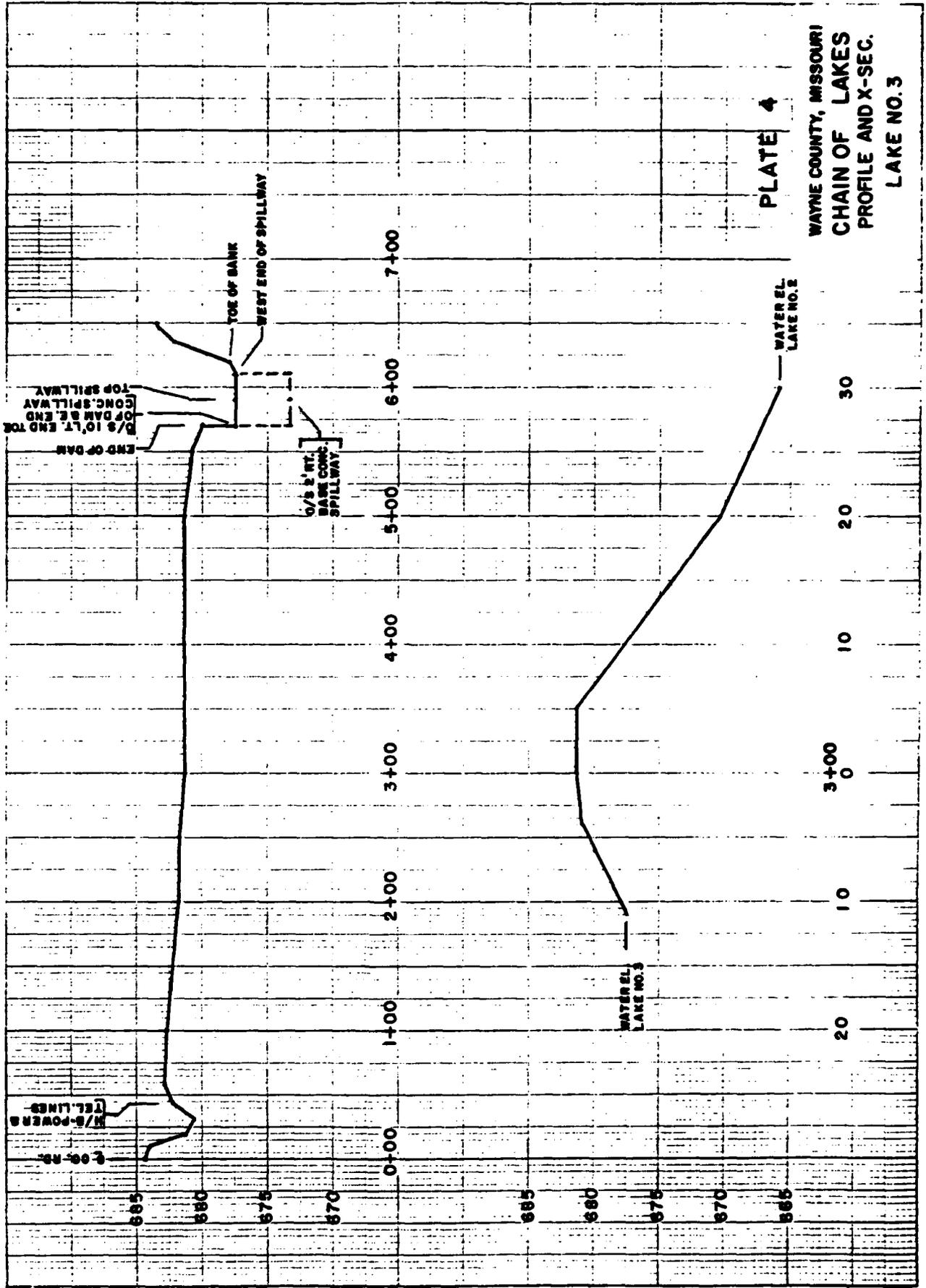


PLATE 4

WAYNE COUNTY, MISSOURI
 CHAIN OF LAKES
 PROFILE AND X-SEC.
 LAKE NO. 3

PROJECT	DAM SAFETY INSPECTION	Page 1 of 2	COMPUTED BY	DATE
SUBJECT	CHAIN OF LAKES	4 APR 1978	MJC	7 APR 78
			CHECKED BY	DATE

WAYNE COUNTY MO. NEAR DES ARC. - GOOSE CREEK

7 1/2 min U.S.G.S Quads. Piedmont, Patterson, Brunot, Des Arc

9 dams located on Des Arc Quad.

Only 3 lower large dams inspected.

No 1 is lower, most 2 - middle 3 Upper

Drainage Area Above:

Dam 1 1326 Acres
 Dam 2 558 "
 Dam 3 525 "

Water Surface Area:

Lake 1 22.3 acres
 Lake 2 12.4 "
 Lake 3 10.4 "

Spillway Rating Tables.

DAM 1		DAM 2		DAM 3.	
Elev.	Q	Elev.	Q	Elev.	Q
640.6	0 cfs	665.5	0 cfs	677.5	0 cfs.
641.0	19	666.0	13	678	48
642.0	200	667	151	679	259
643.0	500	668	375	Top Spill 680	581
644.0	809	Top Spill 669	659	Top dam 681	991
645.0	1364	Top dam 670	1454	682	1877
Top Spill. 646.0	1940	671	3500	683	3200
Top dam 647.5	3013	672	6000	684	5110
648.5	4124				
649.0	5386				
650.0	6990				
651.0	8700				
652.0	10,700				
1" runoff	110.5 AF		46.5 AF		43.75 AF

1	AREA STORAGE			TABLES			3 Elev.	Area	Stor.
	Elev.	Area	Stor.	Elev.	Area	Stor.			
	640.6	22.3A	183A-F	665.5	12.4	82 AF	677.5	10.4	50A
	641.0	22.3	184	666	13.2	88	678	11.0	55
	642.0	24.0	208	667	14.3	100	679	11.7	62
	644.0	28.3	264	668	15.4	113	680	12.5	69
	646.0	32.7	327	669	16.7	125	681	12.9	77
	648.0	37.4	399	670	17.6	138	682	13.5	85
	650.0	42.3	479	671	18.0	150	683	14.02	93
	652.0	47.3	568	672	18.7	162	684	14.6	102

- HYDROLOGY -

1. Frequency rainfalls were obtained for TP-40 and NWS Hydro 35.
2. The SCS Unit hydrograph technique using estimated runoff curve Nos.
3. Time of Concentration computed by Kirpich formula.

$$t_c = \frac{.00013 L^{0.77}}{S^{.385}} \quad \text{where } L = \text{length in ft} \\ S = \text{Fall H/L}$$

Dam 3 - Sub area 525 acres = .92 mi²
 $L = 5.3 \times 2000 = 10600 \text{ ft}$
 $S = (1350 - 660) / 10600 = 0.0651$
 $t_c = \frac{.00013 (1257.93)}{.3493} = .47 \text{ hour.}$

Dam 2 Sub area - 801 acres = 1.25 mi²
 $L = 3.6 \times 2000 = 7200 \text{ feet.}$
 $S = (880 - 640) / 7200 = 0.0333$
 $t_c = \frac{.00013 (933.6)}{.2699} = .45 \text{ hr.}$

Conservative rainfall excess values were used in routing Flood hydrographs through Reservoir Storage Routed (Modified Puls) using results of the 100yr and PMF formulas are.

Time (hrs)	100yr Dam 1		100yr Dam 2		100yr Dam 3	
	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow
1	42	30	17	3	26	17
2	32	32	19	5	18	19
3	48	36	21	7	27	21
4	116	61	37	10	67	38
5	206	105	85	36	112	87
6	1258	369	363	129	712	419
7	1980	2434	866	1109	553	212
8	689	1221	232	395	185	234
9	447	717	154	226	142	153
10	293	502	111	151	91	109
11	226	343	78	112	74	78
12	203	263	75	89	74	75

Peak 6hr 25min 4142 6hr 50min 2595 6hr 30min 2110 6hr 40min 1658

6hr 25min 2271
6hr 20min 2153

PROJECT	DAM SAFETY INSPECTION		Page 2 of 3	COMPUTED BY	DATE	
SUBJECT	CHAIN OF LICES		4 APR 1978	CHECKED BY	DATE	
		Dam 1	Dam 2	Dam 3		
	Maximum Water Surface El. 100 yr. flood	~646	~671	~682		
	Duration - Flow overtop Spillway	0	40 min.	1 hr. 15 min		
<p>Individually dams 2 and 3 would be class. for as small sized low hazard potential and Dam 1 is classified as a small sized high hazard potential dam. The design flood for Dam No. 1 is 1/2 to full PMF. This storm would cover the drainage areas of Dam 2 and 3 also. So they must be designed for PMF realizing they cannot contain the 100 year floods.</p>						
TIME hrs	PMF Inflow	Dam 1 Outflow	PMF Inflow	Dam 2 Outflow	PMF Inflow	Dam 3 Outflow
1	193	104	161	33	165	161
2	218	154	131	102	117	130
3	201	180	102	102	92	101
4	174	182	83	97	77	82
5	155	172	71	84	62	71
6	137	152	65	73	63	65
7	360	220	193	111	251	204
8	474	350	331	207	231	212
9	529	450	374	256	272	274
10	548	507	377	271	272	277
11	556	534	373	287	270	279
12	557	542	371	287	271	279
13	1519	912	862	597	942	576
14	2260	1221	1144	1117	1149	1176
15	2833	2625	1431	1401	1432	1334
16	7190	6200	3597	3588	3617	3212
17	2899	3819	1456	1478	1401	1435
18	2181	2442	1075	1106	1061	1172
19	843	1408	368	545	285	355
20	485	787	212	305	175	209
21	304	542	133	194	108	131
22	229	263	98	132	95	98
23	205	271	96	95	95	95
24	196	226	96	95	95	95
Peak 16:05	7200	16:15 6563	16:05 3607	16:05 3604	16:00 3617	16:00 3612
	Max W.S. El. PMF		Dam No 1 650±	Dam 2 671±		Dam 3 688±
	Duration Above top of Dam		4 hr 10 min	4 hr. 50 min		6 hr. 5 min



PHOTO 1

Dam No. 1
Spillway viewed from right abutment

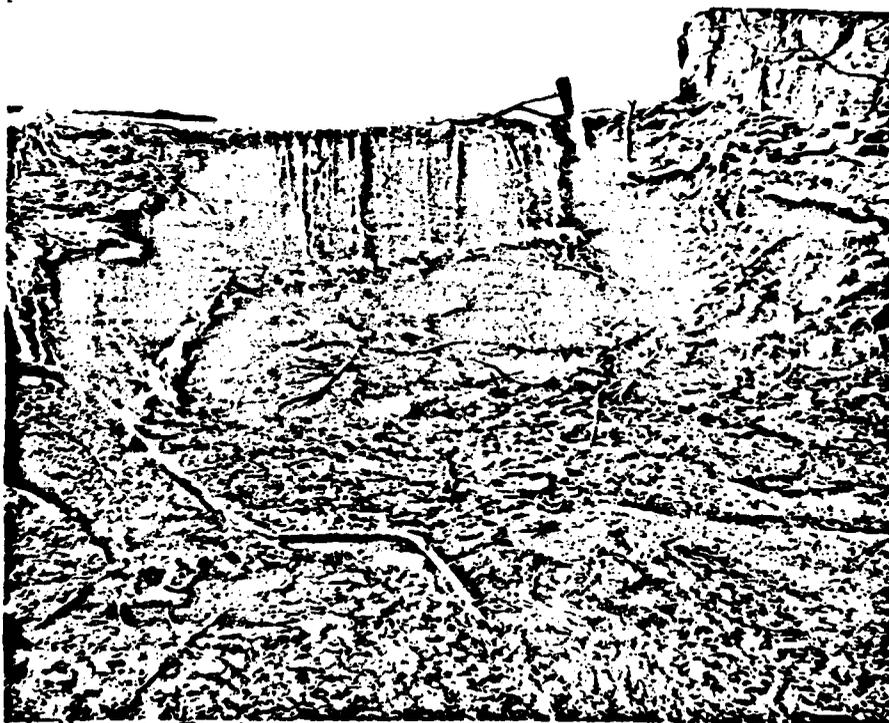


PHOTO 2

Dam No. 1
Spillway - Looking upstream



PHOTO 3 Dam No. 1
Edge of Apron - downstream from spillway



PHOTO 4 Dam No. 1
Damaged area of spillway



PHOTO 5 Dam No. 1
Marshy area at toe



PHOTO 6 Dam No. 1
Embankment crown

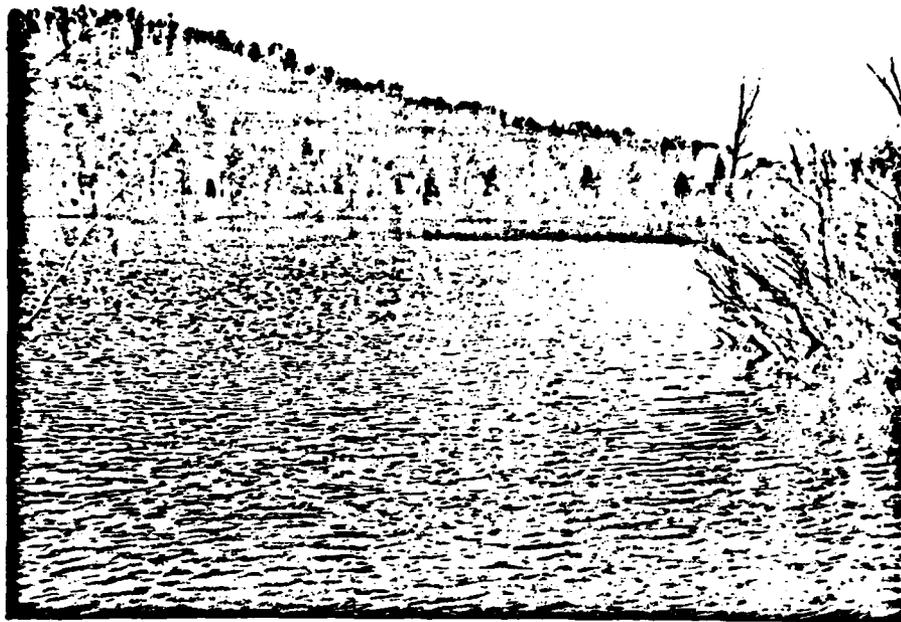


PHOTO 7

Dam No. 1
Upstream face

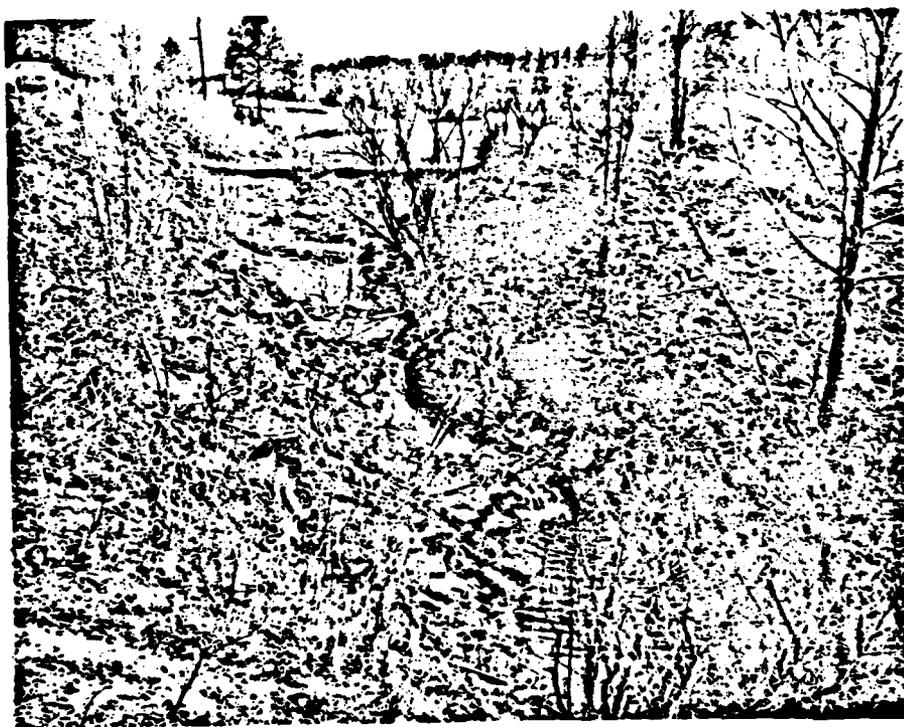


PHOTO 8

Dam No. 2
Spillway



PHOTO 9 Dam No. 2
Downstream slope and exit channel

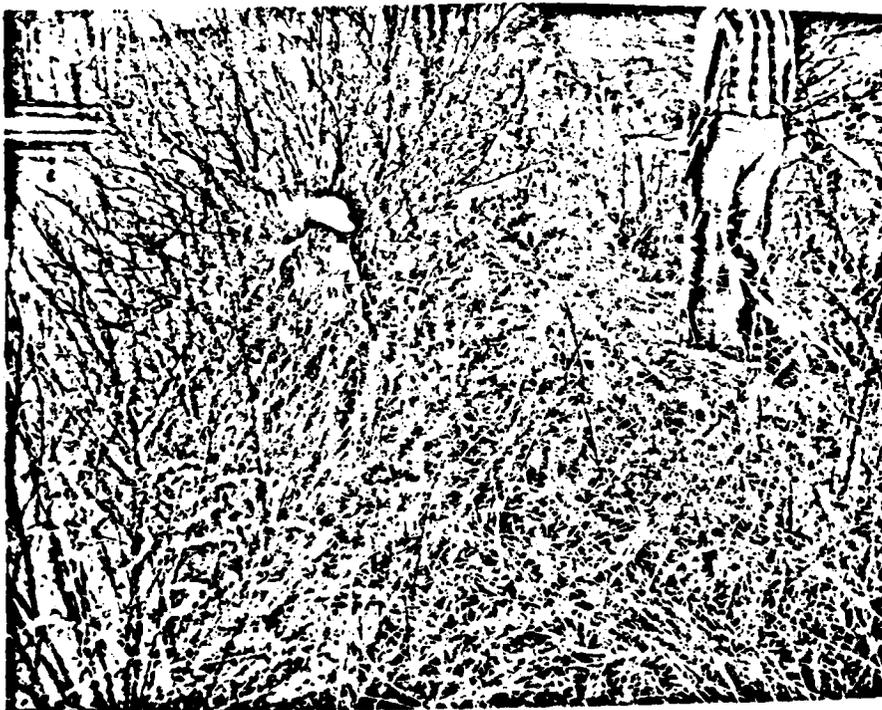


PHOTO 10 Dam No. 2
Crown and upstream slope



PHOTO 11 Dam No. 2
Marshy area at toe

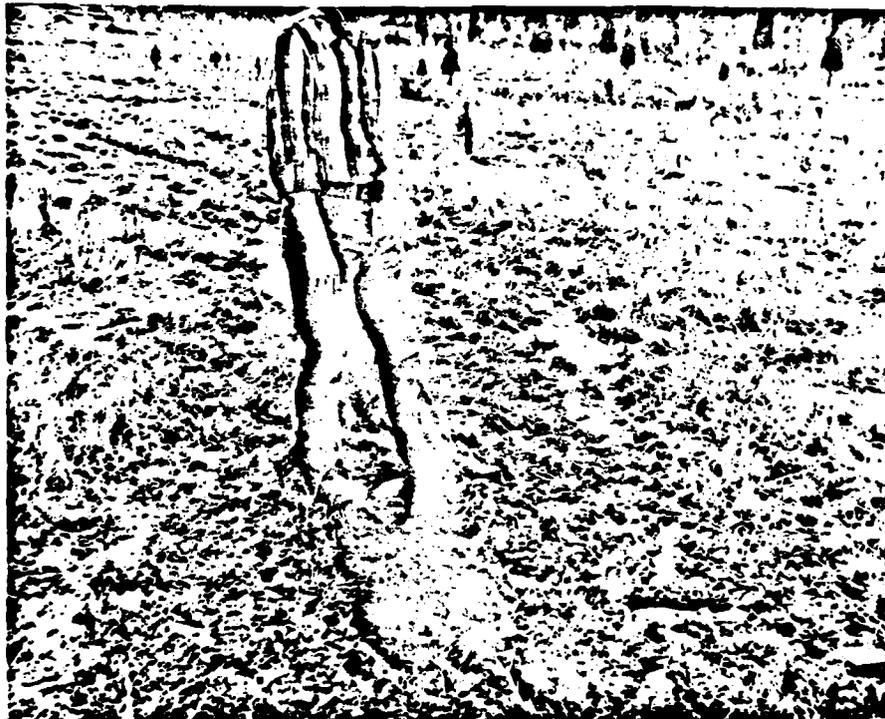


PHOTO 12 Dam No. 2
Seepage area at toe

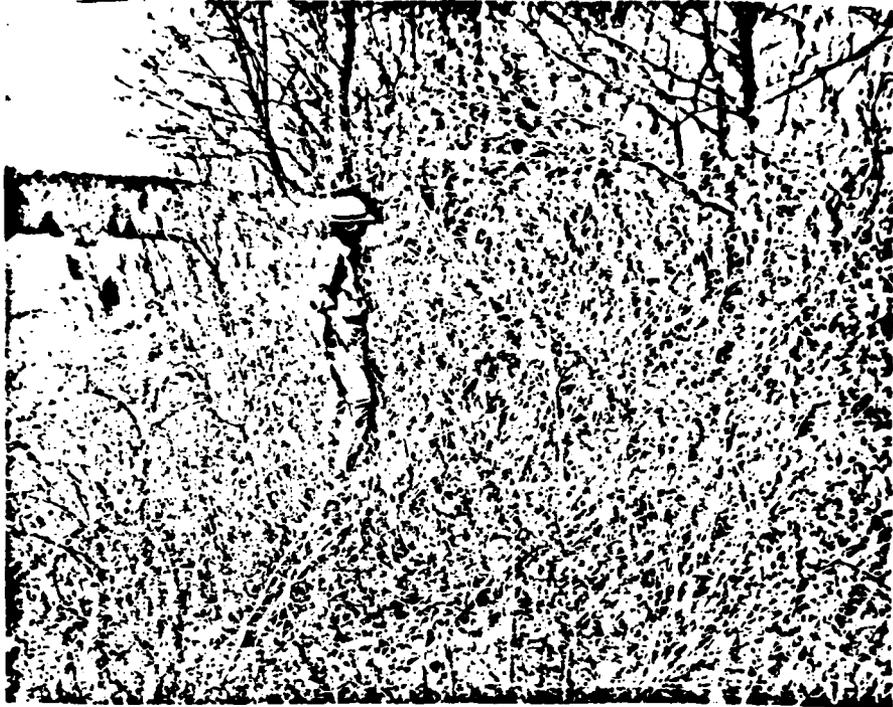


PHOTO 13

Dam No. 2
Steep portion of downstream slope

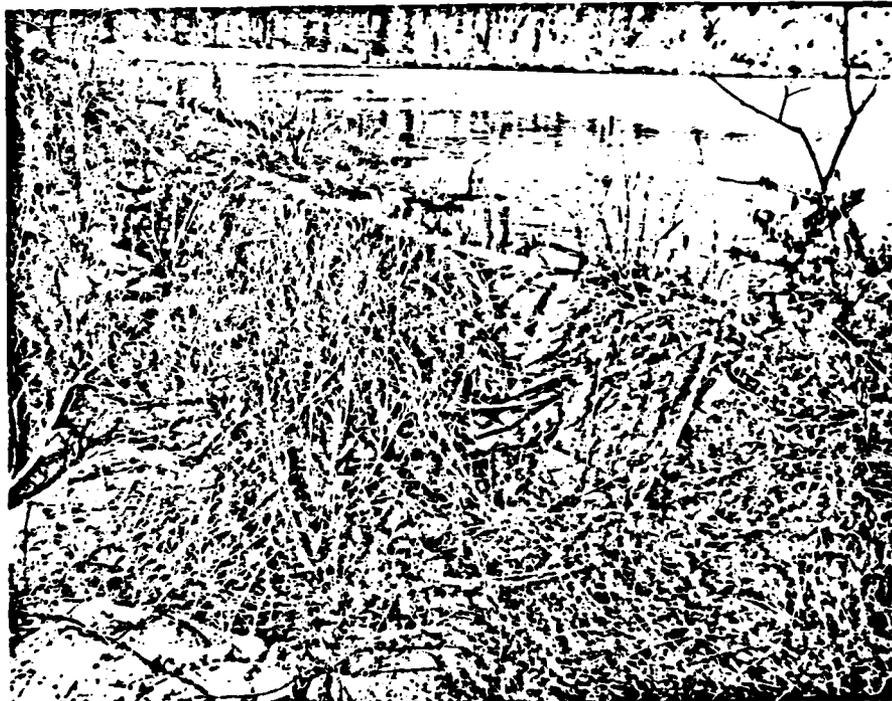


PHOTO 14

Dam No. 3
Spillway



PHOTO 15

Dam No. 3
Remains of spillway area



PHOTO 16

Dam No. 3
Spillway apron and Lake No. 2



PHOTO 17

Dam No. 3
Spillway apron



PHOTO 18

Dam No. 3
Downstream face



PHOTO 19

Housing along creek, downstream

