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NATIONAL PROGRAM OF INSPECTION OF NON-FEDERAL DAMS TENNESSEE. C--ETC(U)
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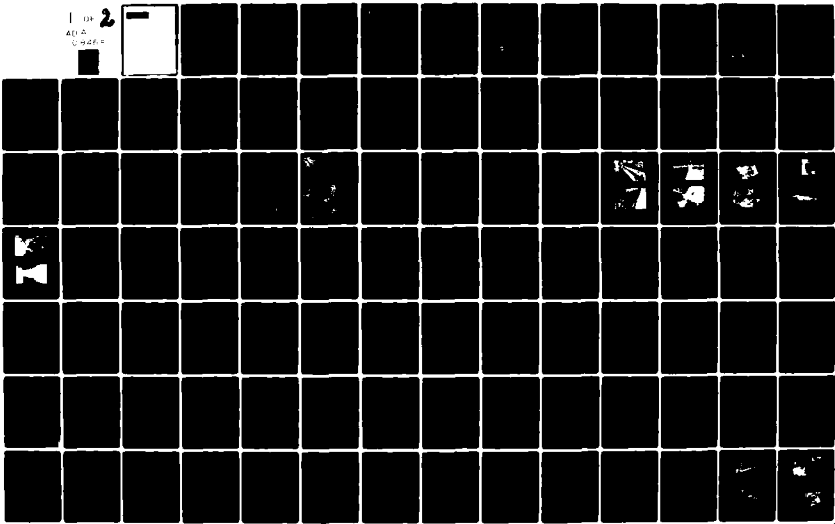

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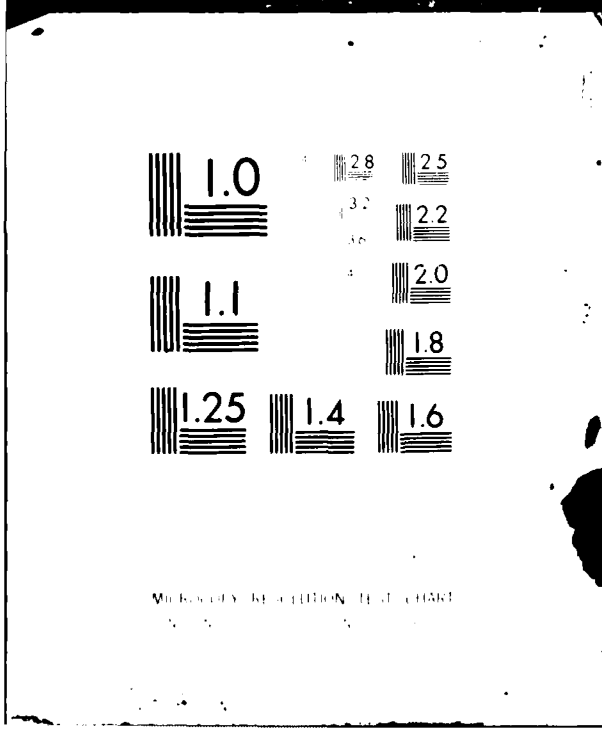
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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

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National Program of Inspection of Non-Federal Dams, Tennessee. Cumberland Springs Lake Dam (Inventory Number TN 12701) near Lynchburg, TN., Moore County, TN., Elk River Basin

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Phase 1 Investigation Report

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National Dam Safety Program
Cumberland Springs Lake Dam, TN
Lynchburg, TN
Moore County, TN
Embankments
Visual Inspection
Structural Analysis

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

Cumberland Springs Dam has an 8.3 acre lake and is located near the head of Hurricane Creek in Moore County, Tennessee. The concrete gravity structure has a maximum constructed height of 33 feet and a length of 192 feet, including a 36 foot long ogee spillway. The spillway section also includes a drawdown pipe that is gated on the upstream face. The concrete dam is reinforced with six buttresses on the downstream face. The exposed surfaces of the buttresses are badly weathered with horizontal cracks 6 inches deep on the vertical faces. A horizontal crack was observed on the downstream face of the dam approximately

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10 feet above the foundation sill. This crack appears to be in a construction "cold" joint. Seeps were found in the east end wall and along the foundation sill between buttresses 1 and 2 and 2 and 3. Numerous springs were flowing immediately below the dam and both abutments. Cumberland Springs Dam is in the small size category and has a downstream hazard potential classification of high by the Corps of Engineers and "I" by the State of Tennessee. On the basis of hydraulic analysis, Cumberland Springs Dam flood storage (15.8 acre-feet) and emergency spillway are inadequate to safely pass the 1/2 Probable Maximum Flood (PMF), which Office of the Chief of Engineers (O.C.E.) Guidelines specify to be the design flood for a dam in the small size and high hazard potential categories. At this time, the dam is considered "unsafe-nonemergency". It is recommended that qualified engineers be engaged to determine the modifications necessary for the project to safely pass the design flood including a stability analysis, also determine source of seeps at the east end and at abutments and propose corrective measures and develop an appropriate warning system.

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 1070
NASHVILLE, TENNESSEE 37202

21 SEP 1981

IN REPLY REFER TO
ORNED-G

Honorable Lamar Alexander
Governor of Tennessee
Nashville, TN 37219

Dear Governor Alexander:

Furnished herewith is the Phase I Investigation Report on Cumberland Springs Dam near Lynchburg, Tennessee. The report was prepared under the authority and provisions of PL 92-367, the National Dam Inspection Act, dated 8 August 1972.

The report presents details of the field inspection, background information, technical analyses, findings, and recommendations for improving the condition of the dam.

Based upon the inspection and subsequent evaluation, Cumberland Springs Dam is classified as unsafe-nonemergency due to insufficient storage and spillway capacity to pass the one-half probable maximum flood.

We do not consider this an emergency situation at this time, but the recommendation concerning project modifications to allow safe passage of the design flood and others contained in this report should be undertaken in the near future.

Public release of the report and initiation of public statements fall within your prerogative. However, under provisions of the Freedom of Information Act, the Corps of Engineers is required to respond fully to inquiries on information contained in the report and to make it accessible for review on request.

Your assistance in keeping me informed of any further developments will be appreciated.

Sincerely,

Kenneth W. Ashley, LTC

1 Incl
As stated

for LEE W. TUCKER
Colonel, Corps of Engineers
Commander

CF:
Mr. Robert A. Hunt, Director
Division of Water Resources
4721 Trousdale Drive
Nashville, TN 37220

Accession For

Dist
A

PHASE I INSPECTION

CUMBERLAND SPRINGS DAM

MOORE COUNTY, TENNESSEE

Prepared By:

WINSETT-SIMMONDS, CONSTERDINE & ASSOCIATES, INC.

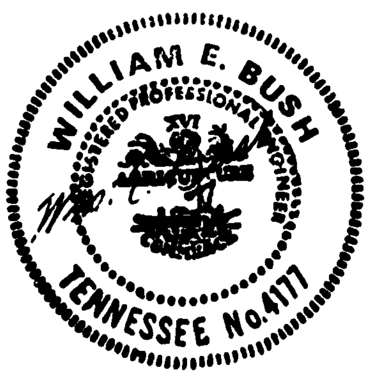
PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
TENNESSEE

Name of Dam	Cumberland Springs Dam
County	Moore
Stream	Tributary Hurricane Creek
Date of Inspection	May 13, 1981

This investigation and evaluation report was prepared for the Tennessee Department of Conservation, Division of Water Resources by Winsett-Simmonds, Consterdine & Associates, Inc., P.O. Box 40045, Memphis, TN 38104.

Prepared By:

Wm. E. Bush, P.E., Director
Civil & Water Resources Engineering



ABSTRACT

Cumberland Springs Dam has an 8.3 acre lake and is located near the head of Hurricane Creek in Moore County, Tennessee. The concrete gravity structure has a maximum constructed height of 33 feet and a length of 192 feet, including a 36 foot long ogee spillway. The spillway section also includes a drawdown pipe that is gated on the upstream face. The concrete dam is reinforced with six buttresses on the downstream face.

The exposed surfaces of the buttresses are badly weathered with horizontal cracks 6 inches deep on the vertical faces. A horizontal crack was observed on the downstream face of the dam approximately 10 feet above the foundation sill. This crack appears to be in a construction "cold" joint. Seeps were found in the east end wall and along the foundation sill between buttresses 1 and 2 and 2 and 3. Numerous springs were flowing immediately below the dam and both abutments.

Cumberland Springs Dam is in the small size category and has a downstream hazard potential classification of high by the Corps of Engineers and "I" by the State of Tennessee.

On the basis of hydraulic analysis, Cumberland Springs Dam flood storage (15.8 acre-feet) and emergency spillway are inadequate to safely pass the ½ Probable Maximum Flood (PMF), which Office of the Chief of Engineers (O.C.E.) Guidelines specify to be the design flood for a dam in the small size and high hazard potential categories.

At this time, the dam is considered "unsafe-nonemergency". It is recommended that qualified engineers be engaged to determine the modifications necessary for the project to safely pass the design flood including stability analysis, also determine source of seeps at the east end and at abutments and propose corrective measures and develop an appropriate warning system.

TABLE OF CONTENTS

OVERVIEW PHOTO

PHASE I INSPECTION

CUMBERLAND SPRINGS DAM

MOORE COUNTY, TENNESSEE

SECTION 1 - GENERAL

1.1 Authority - The Phase I inspection of this dam was carried out under the authority of the Tennessee Code Annotated 70-2501 to 70-2530, "The Safe Dams Act of 1973", in cooperation with the Corps of Engineers under the authority of PL 92-367, "The National Dam Inspection Act".

1.2 Purpose and Scope - This report is prepared under guidance contained in Department of the Army, Office of the Chief of Engineers, Recommended Guidelines for Safety Inspection of Dams, for a Phase I investigation. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general conditions of the dam is based upon available data and visual inspections. Detailed investigation and analysis involving topographic mapping, subsurface investigation, testing and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. Additional data or data furnished containing incorrect information could alter the findings of this report.

It is important to note that the condition of the dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions will be detected.

1.3 Past Inspections - An inspection trip was made to Cumberland Springs Dam by the Division of Water Resources, State of Tennessee, and Nashville District Corps of Engineers on February 12, 1980. (See Appendix F).

1.4 Miscellaneous Details - On the day of the Phase I inspection, the weather was clear with temperatures in the 70's and the wind was calm. The level of the lake was approximately at the crest of the emergency spillway.

1.5 Inspection Team Members - Field inspection was performed by the following Winsett-Simmonds, Consterdine & Associates, Inc. personnel:

William E. Bush, P.E.
Civil Engineer

Dr. Fred H. Kellogg, P.E.
Geotechnical Engineer

The team was accompanied by Mr. George Moore of the Tennessee Division of Water Resources and Mr. Paul Bluhm of the Nashville District Corps of Engineers.

SECTION 2 - PROJECT DESCRIPTION

2.1 Location - The dam is located in Moore County Tennessee, near the headwaters of Hurricane Creek. It can be located on the USGS map, "Cumberland Springs, 79SE Tennessee" at latitude 35°20'25" and longitude 86°17'46". (Appendix B, Location Map).

2.2 History of the Project - The construction history of Cumberland Springs Dam was obtained from Mr. Conner Motlow. Cumberland Springs Lake Dam is a concrete structure that was built after World War I by Mr. Conner Motlow's family. The first structure was constructed without buttresses and failed during a large storm shortly after construction was completed. The existing structure was constructed of reinforced concrete around 1921 using buggy axles, springs and light railroad rails as reinforcement. The buttresses were constructed after the main dam was completed, but were tied into the dam with reinforcement. The top of the dam is two feet wide and the bottom is ten feet wide. The base of the dam was keyed into rock several feet deep. The original constructed height of the dam was reported to be 33 feet. The concrete mix was reported to be a 2-2-2 with crushed limestone used for the aggregate.

A penstock was later added to the dam to operate a grist mill and small generator that was located at the left abutment. Traces of the mill remain; the penstock has been sealed with concrete. A fish ladder was also attached to the downstream side of the dam near the left abutment. The fish ladder was destroyed by blasting and the concrete debris was left immediately below the dam.

During the second World War, the dam and lake was used by the U.S. Army for recreation and training purposes. During this period, a ledge of rock was blown off upstream from the dam by the Army that increased the flow of the springs in the abutments. These springs had originally appeared over a long period of time.

The dam was repaired in 1976 by guniting portions of both the upstream and downstream faces of the dam.

2.3 Description of Dam and Appurtenances

2.3.1 Dam - Cumberland Springs Dam is constructed of reinforced concrete. It has a maximum constructed height of 33 feet and a length of 192 feet. At the crest elevation of 1001.8 feet, the 2 foot wide crest has a steel walkway with handrails the entire length of the top of the dam. On the downstream face are six buttresses that vary from 2 feet to 5 feet in width and the downstream buttress slopes vary from 50-60 degrees. (See Appendix B and Photograph 2). The dam downstream and upstream faces are 1V on 0.12H.

2.3.2 Emergency Spillway - The emergency spillway is of the ogee type, 36 feet long and 1.8 feet deep. The spillway is located near the east abutment; the crest of the weir is at elevation 1000 feet MSL. The spillway discharges down the downstream face of the dam into a plunge pool estimated to be 5 feet deep. (See Photographs 3 and 4).

2.3.3 Drawdown Facility - The drawdown facility has a valve attached to the upstream face of the dam at approximately the center of the ogee spillway. The drawdown exits the downstream face of the spillway through a rectangular opening. According to the owner, the valve was inoperable at the time of inspection and had not been opened in several years. (See Photograph 4).

SECTION 3 - INSPECTION FINDINGS

3.1 Specific Findings

3.1.1 Geology - The dam rests on a thin-bedded, flat-lying limestone with shale interbeds and chert veins, belonging to the Fort Payne Formation. This is usually highly chertified limestone of lower Mississippi age. The dam site is located in the lower part of the formation, where there is less chertification and shale interbeds that increase in frequency as the base of the formation is approached. The bottom member of the Fort Payne is the Moore Shale, which is about 7 feet thick. The top of this shale may be outcropping at the concrete sill location, about 400 feet below the dam. This shale gives an odor of petroleum when rubbed vigorously, and probably contains sulphur. The limestone is highly soluble, for a Paleozoic Limestone, as indicated by the widespread deposits of tufa along the right abutment. The aggregate in the concrete, as seen from the concrete debris of the old, washed out dam, contains considerable amounts of chert, both as veins in the limestone fragments and as aggregate particles. Very little chert was seen in the bedrock in place.

The overlying Cathys and Leipers limestone outcrop behind the abutments and do not affect the dam. The underlying Chattanooga Shale is at an undetermined distance beneath the dam, and it with the Moore shale member of the Fort Payne, give reasonable assurance that there are no cavernous solution channels under the dam.

The major system strikes approximately east and west. The main joint system is at right angles to this. The solution channels generally follow the joint. The major joints are at about 30 degree angles to the dam, which runs about north 60 degrees west.

3.1.2 Dam

Left Abutment - Just upstream from the dam, the abutment is protected with splashed concrete. The abutment itself rises about 5 feet above the pool, then slopes gently back from the dam for several hundred feet before rising as a high ridge. Six springs come out of small solution channels within the first 50 feet below the dam. These are located between the base of the abutment and about 15 feet below the top of the dam. A large spring is flowing about halfway up the abutment face, about 100 feet downstream. Another spring was observed at the base of the abutment about 20 feet further downstream. The abutment downstream is a nearly vertical face of flaggy limestone rising about 25 feet from the creek level, then sloping back gently.

A fish ladder had been built at the left abutment. This was removed by dynamiting, and can be seen about 50 feet below the dam at the foot of the abutment as a heap of concrete fragments.

A concrete wall was built against the dam, at the east abutment, for construction of a grist mill. Two springs are coming out of the concrete in this wall, one about 5 to 7 feet below the walkway, and the other about 20 feet below. Another comes out at the top of a vertical concrete beam cast against the wall, about 15 feet below the walkway. The walkway is about 2 feet above the top of the dam. Steel reinforcement and an old steel wheel, along with a vertical and a horizontal concrete beam, both well weathered, are all that remain of the mill.

Right Abutment - The right abutment rises from the pool gradually to a height about ten feet above water, then flattens for a considerable distance, beyond which, is a high hill. Below the dam, a rock ledge extends almost to the spillway section. Trees, mainly 4 to 6 inches in diameter with some up to 12 inches, are growing here. Near the base of the abutment and on into the stream, are 15 to 20 chunks of concrete from the old dam. Some of the axles used for reinforcement are protruding from the concrete. Below the dam, the abutment slopes about 1 on 1 to 2 on 1. The rock is coated with tufa. About 75 feet below the dam, a large stream discharging several cfs, is flowing out of a solution channel in the rock. A considerable amount of tufa has been deposited here. Two small pipes have been placed in the rock (about 1.5 inches in diameter, and both are flowing). About 300 feet downstream, a stream, probably spring fed, is flowing off the abutment hill. The limestone here lies in flat sections, about 0.5 to 2 inches thick.

End Walls - The end walls of the dam are keyed into rock and supported by buttresses at varying intervals. The buttresses are badly weathered. The weathering is less in the buttresses nearest the west abutment. Weathering extends well back in the construction joints, about 10 feet above the base of the dam. These joints are open some 10 to 15 feet in length and 6 inches into the concrete. The buttresses are undermined. Iron stained water was noted between the first and second buttresses west of the spillway, and also between the second and third. The upstream faces have been gunited and are in good shape. The concrete in the dam used crushed limestone aggregate. According to Mr. Motlow, a 2:2:2 (cement-fine aggregate-course aggregate) mix was used. The water--cement ratio is not known. Judging from chunks of concrete washed downstream from the first dam, the maximum size of aggregate is about 6 inches. The aggregate includes significant quantities of chert.

The rock at the base of the buttresses west of the spillway was shale. This shale is hard, well cemented, limey, and does not slake. Some slaking shale was noted downstream.

Cutoff - A cutoff trench was cut along the base of the dam, according to Mr. Connor Motlow. The width of the base is

10 feet. No grouting has been done. The cutoff seems to be effective, as no boils were seen downstream. The end walls were keyed into rock at the abutment. There is considerable leakage around the east abutment, but the water is clear.

3.1.3 Spillway - The emergency spillway downstream face was repaired with gunite in 1976 and appears to be in good condition at the the time of inspection. The steep downstream face of the spillway would appear to cause the nape to pull away from the face during large discharges, creating negative pressures on the face of the spillway and excessive erosion at the base of the spillway.

3.1.4 Static and Seismic Stability Assessment - The actual margin of safety for static stability cannot be determined since the engineering data required for an analytical stability analysis are not available without extensive foundation data, field measurement, and construction drawings. Consequently, the assessment of structural stability must be based on visual evidence, engineering judgement, and hydraulic and hydrologic studies. On this basis, no conditions are apparent that could reasonably be expected to pose an immediate threat to the stability of the dam under normal operating conditions. However, if unattended, the seepage at the abutments and downstream of the dam could eventually endanger project safety.

The dam is in Seismic Zone 1. No record of any stability analysis could be found.

3.1.5 Downstream Inspection and Hazard Classification - The downstream hazard potential classification for Cumberland Springs Dam is high. There are two houses at the stream bank elevation and two houses at a slightly higher elevation plus an improved county road all within the probable flood path in the event of a dam failure. All houses and roads are within 7500 feet of the dam site.

3.1.6 Hydrology and Hydraulics - According to O.C.E. Guidelines, dams with a high hazard, small size classification should have storage and spillway capacity to pass the ½ PMF without overtopping the dam. The Probable Maximum Precipitation (PMP) of 29.2 inches in six hours yields a ½ PMF of 12.41 inches. Time of concentration was estimated to be 0.88 hours and flood storage from normal pool to the low point of top of dam is estimated to be 15.8 acre-feet. Routing of the ½ PMF (Antecedent Moisture Condition II) produced a peak outflow of 14,903 cfs, which overtopped the dam by 7.0 feet. This storm produced a flow over the dam for six hours.

The 100-year 6-hour (AMC III) flood was routed through the structure. Cumberland Springs Dam was overtopped by 3.9 feet with flows lasting 5 hours.

3.2 Conclusions and Recommendations

3.2.1 Conclusions

Visual inspection reveals no conditions which could reasonably be expected to pose an immediate threat to structural stability under normal operating conditions with discharges up to the top of the dam. However, on the basis of engineering judgement and visual observations, and given the depth and duration of overtopping resulting from the ½ PMF storm (Section 3.1.6) it would appear that the margin of safety against overturning and/or sliding of the overflow and spillway sections would be inadequate.

Cumberland Springs Dam has been standing for a long time, but it is difficult to assess the stability with any assurance, without detailed knowledge of the concrete reinforcement and condition of the rock under the dam. While the limestone must be considered as soluble from a geological point of view, solution channels develop slowly over a period of 50 to 100 years. The presence of sulphur-bearing, organic shale in this limestone is cause for concern. This shale, when used as aggregate, has adverse chemical reactions with the concrete and is probably one cause of the severe deterioration noted. In the rock below the dam, the bond between thin layers of rock can be weakened, and possibly in conjunction with the undermining of the buttresses, lead to a sliding failure

Except for deterioration of the exposed concrete in the buttresses along the downstream face, and erosion of the foundations of buttresses and spillway, the concrete structure appears to be sound.

Most of the seepage evidently flows through the natural rock in the valley walls. However, if left unattended, the seepage in the east end wall of the dam could eventually threaten project safety.

The seismic resistance of this dam is unknown but under this program dams in Seismic Zone 1 may be assumed to be adequate against seismic loading if they are judged adequate in static stability requirements.

Hydraulic analysis indicates that the dam's spillway is inadequate to pass the design flood. The storm hydrograph resulting from the ½ PMF will overtop the dam a maximum depth of 7.0 feet with a total duration of 6 hours. Since the emergency spillway can safely pass only a small portion of the design flood (½ PMF), its spillway capacity is considered seriously inadequate.

In accordance with Provisions of the Corps of Engineers Memorandum ETL 1110-2-234, Cumberland dam has a seriously inadequate spillway and is considered unsafe-nonemergency.

3.2.2 Recommendations - Remedial work should begin as soon as practical. The dam's condition should be checked periodically until remedial work is begun. Qualified engineers should be engaged to:

a. Study the hydrology and hydraulics associated with the project and recommend modifications that will allow the project to safely regulate the design flood,

b. Perform analyses to check dam stability under normal and flood conditions,

c. Monitor the abutment seepage flow by installing a weir downstream from the dam, to establish the present base flow and thereby the ability to determine if there is a sudden increase in the base flow which would indicate a pending failure.

d. Recommend measures to stop the seepage in the east end wall.

e. Recommend measures to repair the erosion of the foundation of the buttresses and spillway,

f. Recommend measures to repair the buttress surface concrete,

g. Develop an emergency action plan to alert downstream residents in the event a major problem rises with the dam.

h. Develop an inspection and maintenance program for the dam to be carried out at least annually.

It is also recommended that the owner should maintain the drawdown gate so that it remains operable.

SECTION 4 REVIEW BOARD FINDINGS

The Interagency Review Board for the National Program of Inspection of non-Federal Dams met in Nashville on 6 August 1981 to examine the technical data contained in the Phase I investigation report on Cumberland Spring Dam. The Review Board considered the information and recommended that the condition classification be changed from "significantly deficient" to "unsafe-nonemergency." They agreed with other report conclusions and recommendations. A copy of the letter report presented by the Review Board is included in Appendix H.

APPENDIX A

DATA SUMMARY SHEET

APPENDIX A
DATA SUMMARY SHEET

A.1 DAM - Cumberland

A.1.1 Concrete buttress

A.1.2 Dimensions and Elevations - Elevations were determined by using water surface elevation as shown on quad "Cumberland Springs, 79 SE".

a.	Crest length	192.0 feet
b.	Crest width average	2.0 feet
c.	Max. constructed height	33 feet (from Owner)
d.	Height above sill	25 feet
e.	Crest elev.	1001.8 feet
f.	Emergency Spillway elev.	1000.0 feet
g.	Embankment slope, U/S (from water surface to crest)	Vertical
h.	Embankment slope, D/S (from lower surface to crest)	Vertical
i.	Size classification	Small

A.1.3 Zones, Cutoffs, Grout Curtains — Keyway cut in rock

A.1.4 Instrumentation — None

A.2 RESERVOIR AND DRAINAGE AREA

A.2.1 Reservoir - (Normal pool elevation 1000.0', 1.8 feet below the effective crest).

a.	Surface area	8.3 acres
b.	Length of pool	1900 feet
c.	Capacity (Normal pool)	70 acre-feet (est)
d.	Maximum surface area	9.2 acres
e.	Flood storage	15.8 acre-feet

A.2.2 Drainage Area

a.	Size - 2331 acres (3.64 square miles)	
b.	Characteristics:	
	Average watershed slope	1.0%
	soil	Mount View-Dickson-Guthrie
	cover	Open land 25%; Woodland 75%
c.	Runoff PMF (AMC II)	24.82 inches
d.	Runoff ½ PMF (AMC II)	12.41 inches
e.	Runoff P_{100} (AMC III)	3.65 inches

A.3 OUTLET STRUCTURES

A.3.1 Service Spillway - None

A.3.2 Emergency Spillway

a.	Crest elevation	1000 feet
b.	Depth	1.8 feet
c.	Bottom width	36 feet
d.	Maximum capacity	277 cfs

A.4 HISTORICAL DATA

A.4.1	Construction Date	1921
A.4.2	Designer	Unknown
A.4.3	Builder	Motlow Family
A.4.4	Owner	Connor Motlow
A.4.5	Previous Inspection	TN Division of Water Resources February 12, 1980
A.4.6	Seismic Zone	1

A.5 DOWNSTREAM HAZARD DATA

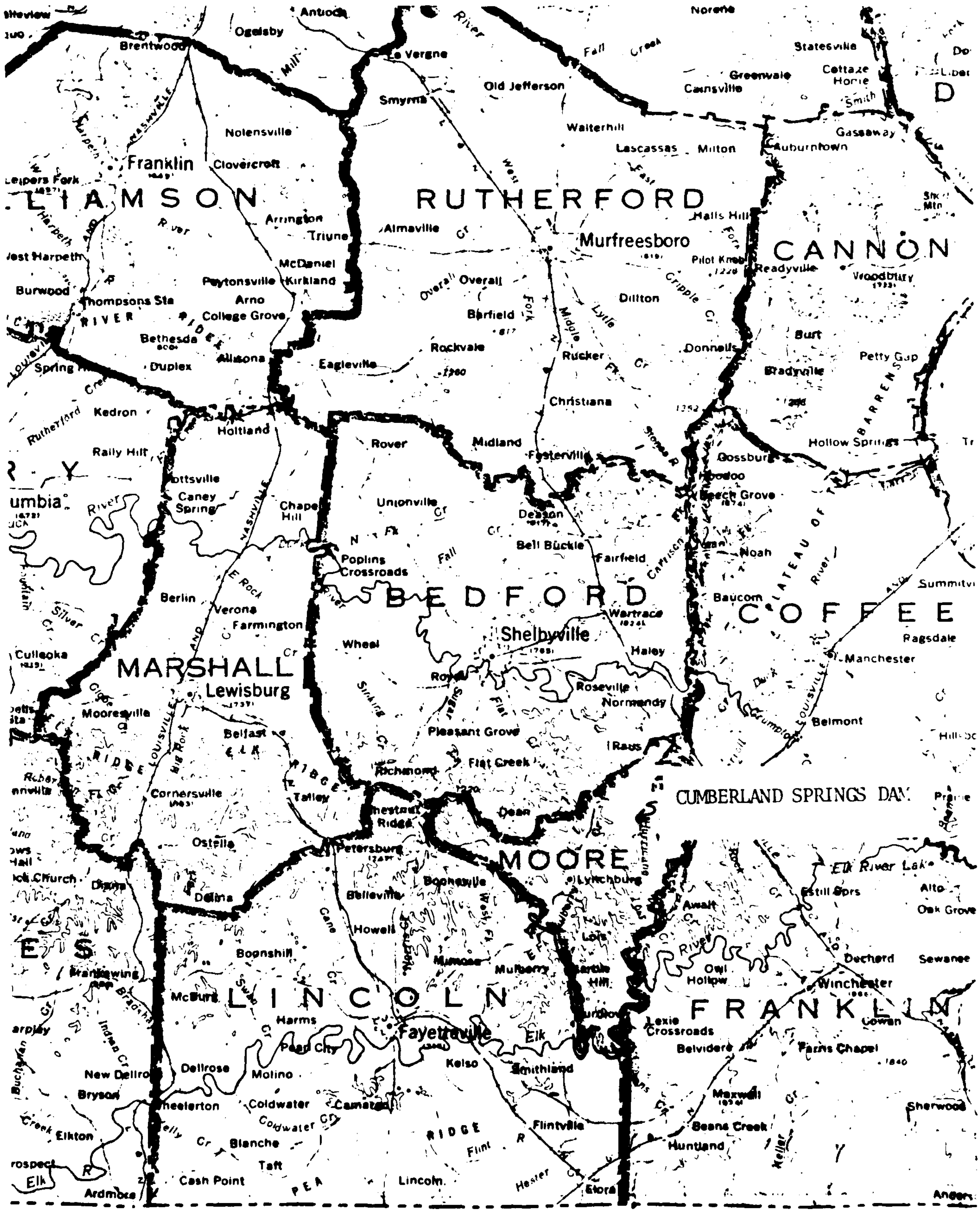
A.5.1 Downstream Hazard Potential Classification

a.	Corps of Engineers	High
b.	State of Tennessee	1

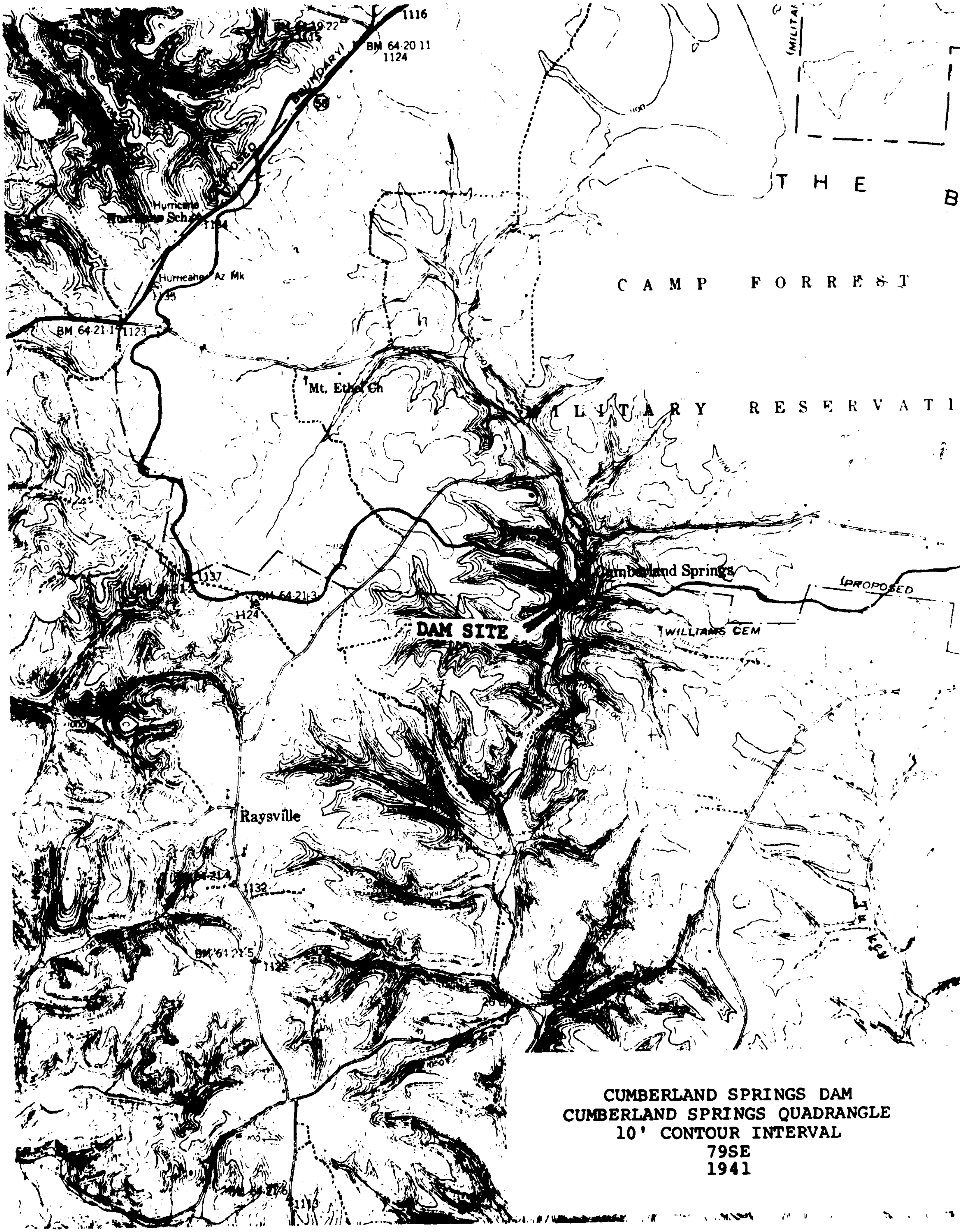
A.5.2	Persons in Probable Flood Path	12 (est)
A.5.3	Downstream Property	4 houses in Probable Flood Path
A.5.4	Warning Systems	None

APPENDIX B

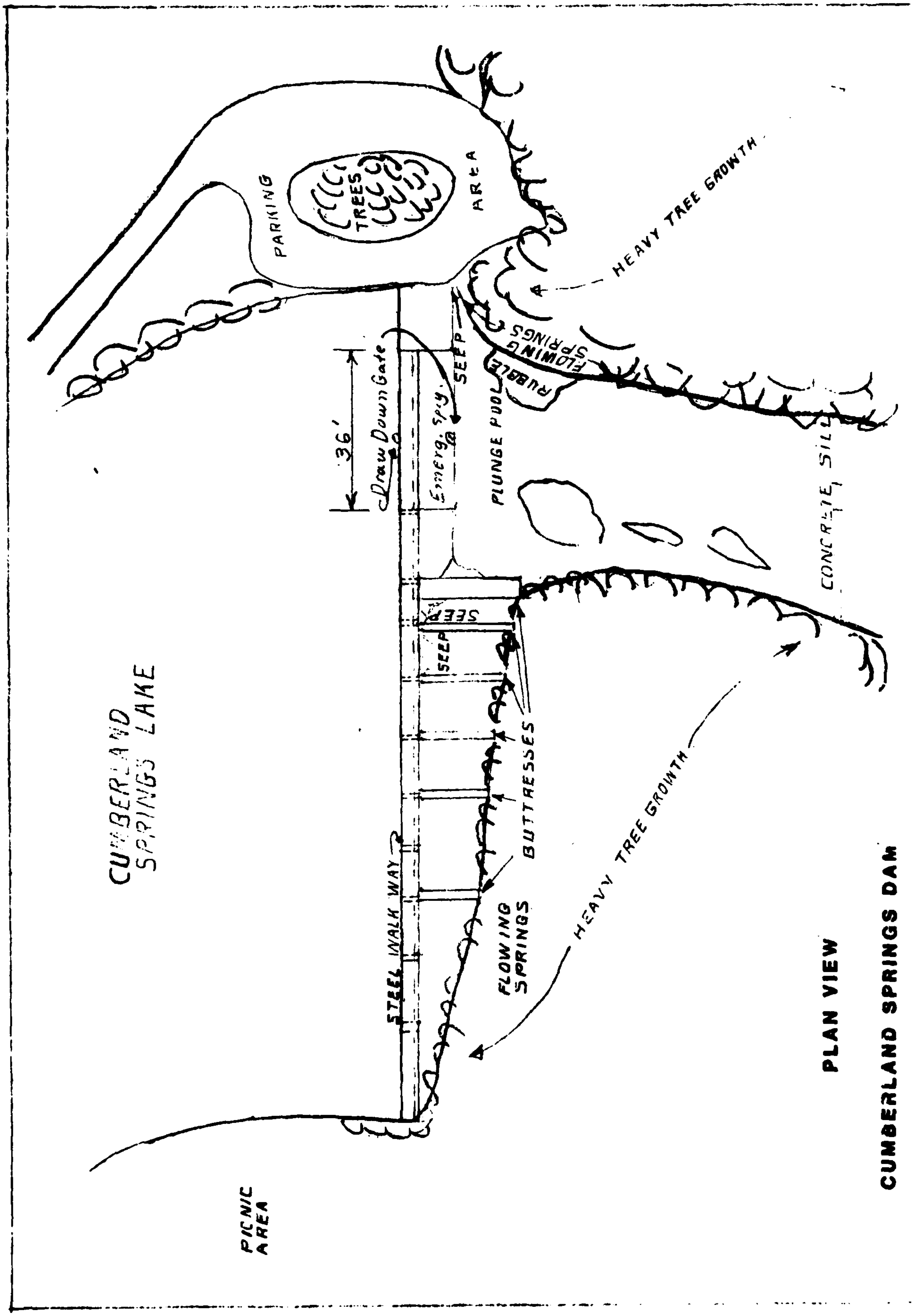
SKETCHES AND LOCATION MAPS



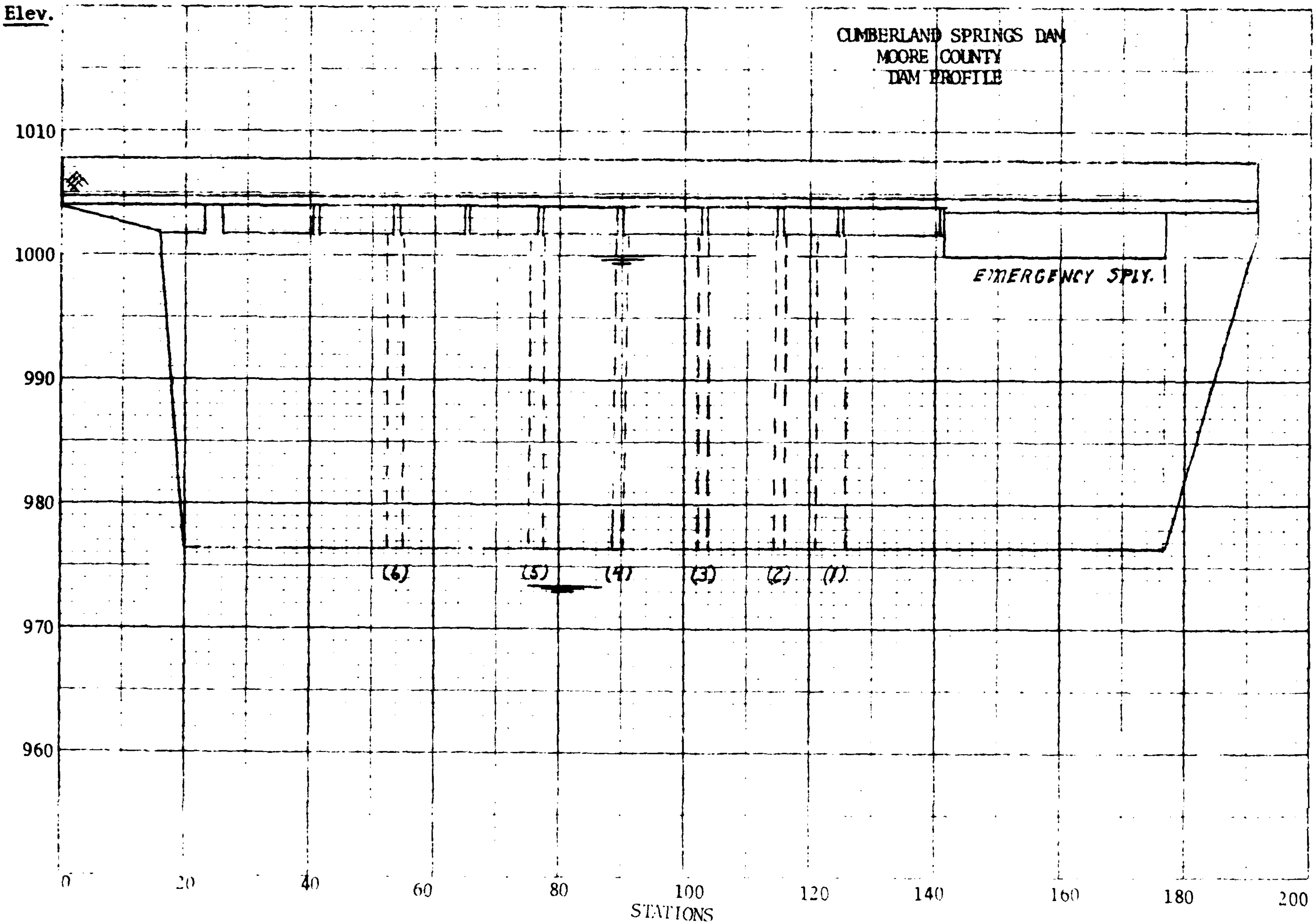
LOCATION MAP



CUMBERLAND SPRINGS DAM
CUMBERLAND SPRINGS QUADRANGLE
10' CONTOUR INTERVAL
79SE
1941



PLAN VIEW
CUMBERLAND SPRINGS DAM


CUMBERLAND SPRINGS DAM
MOORE COUNTY
DAM PROFILE
Elev.
1010
1000
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980
970
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EMERGENCY SPLY.
(6)
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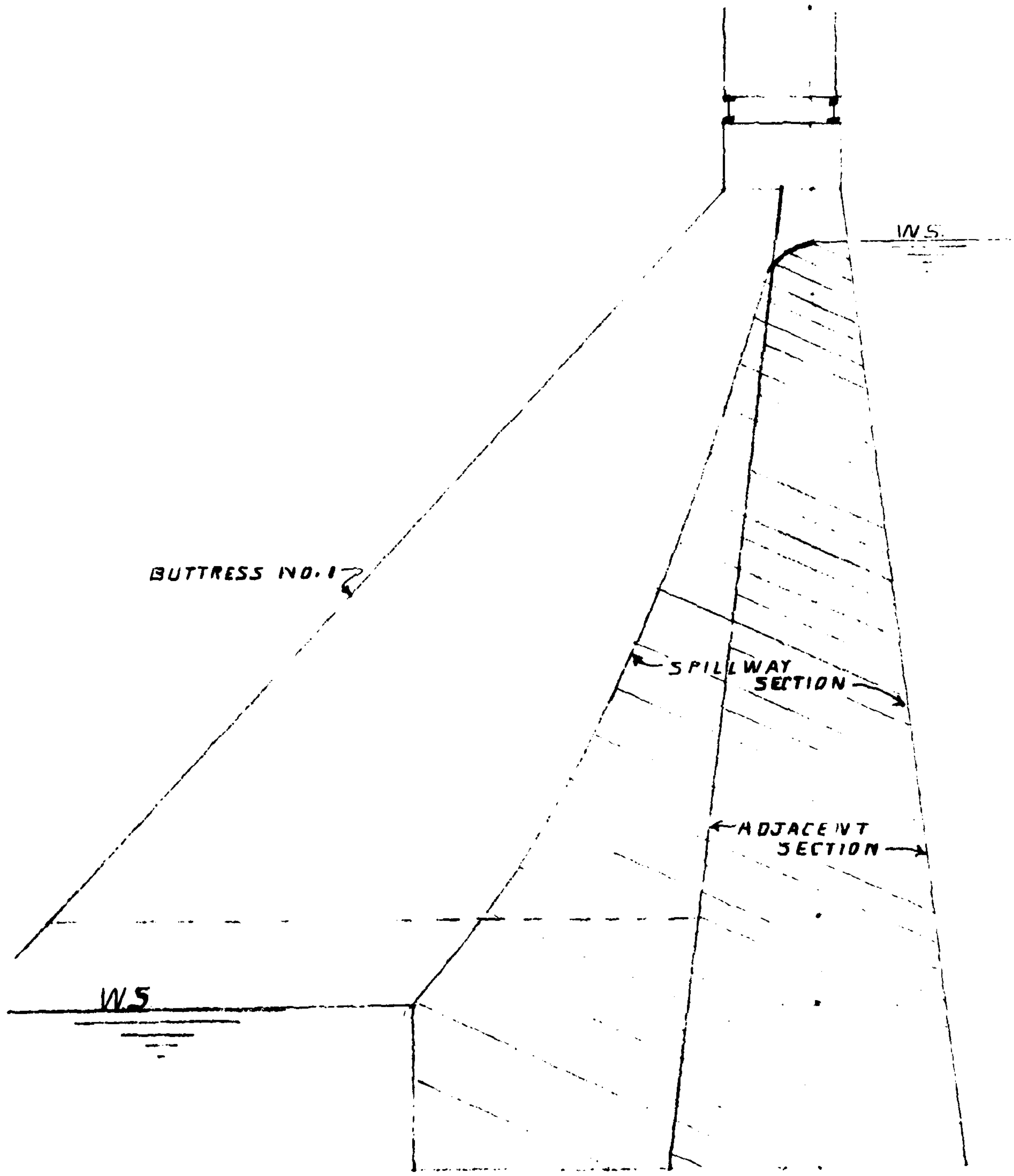
STATIONS

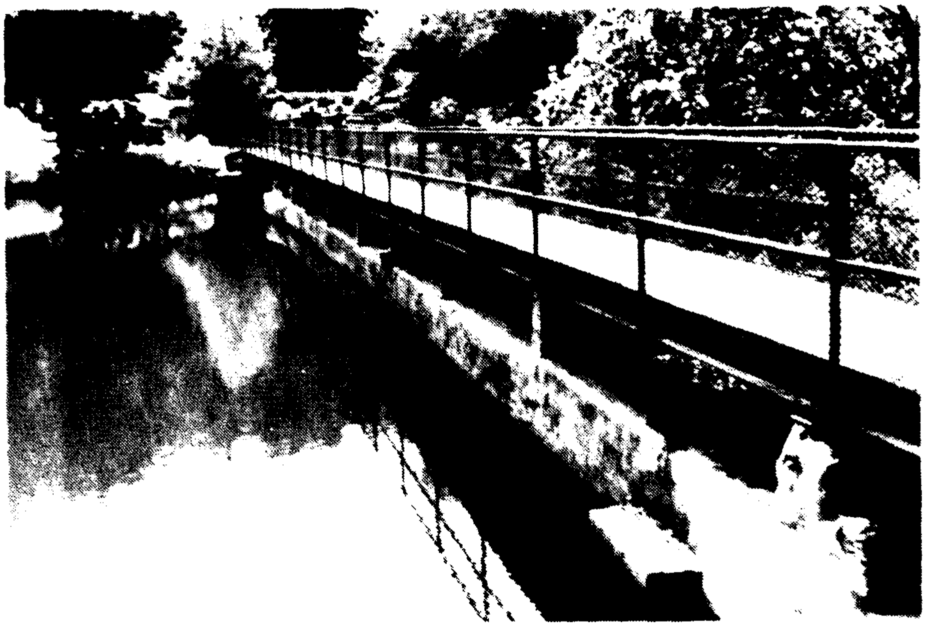


Note: Section reconstructed from field measurements and interview with owner.

SPILLWAY SECTION

APPENDIX C

PHOTOGRAPHIC RECORD



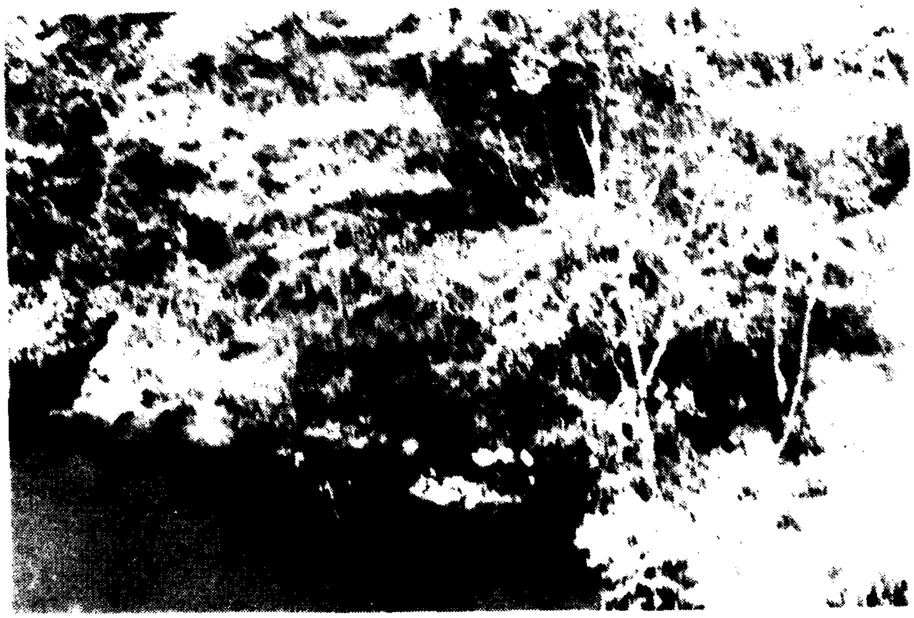
1. Top of dam and upstream face. From west abutment.

2. Downstream face of Cumberland Springs Dam. Note erosion of buttresses.

3. Emergency spillway section at top of Cumberland Springs Dam. Note drawdown gate hoist on upstream face of dam and at center of spillway.

4. Bottom of emergency spillway section showing plunge pool and drawdown pipe opening. Note erosion of concrete at bottom of spillway and under Buttress No. 1.

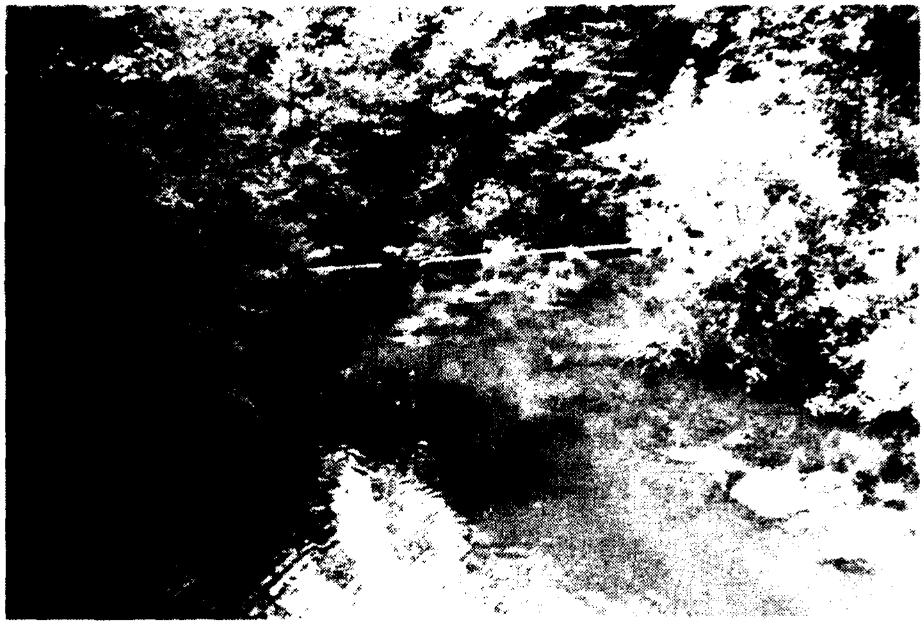
5. East abutment immediately below dam. Note flowing spring all along abutment.



6. West abutment immediately below dam. Note flowing springs.

7. Seepage between Buttress No. 1 and 2. Note red color and oily sheen.

8. Seepage between Buttress No. 2 and 3 at base of dam.



9. Concrete sill across channel approximately 200 feet below dam.

10. Cumberland Springs lake.

APPENDIX D

INSPECTION TEAM TRIP REPORTS

TRIP REPORT
CUMBERLAND SPRINGS DAM
MOORE COUNTY, TENNESSEE

GENERAL ENGINEERING OBSERVATIONS
13 May 1981

GENERAL. An engineering inspection of the Cumberland Springs Dam was made with Dr. Fred Kellogg, Kellogg Engineering. The team was accompanied by Mr. George Moore, Tennessee Division of Water Resources and Mr. Paul Bluhm, Nashville District Corps of Engineers. The weather was clear with temperatures in the 70's. The wind was calm. The lake level was at the crest of the emergency spillway.

CONSTRUCTION HISTORY. The construction history of Cumberland Springs Dam was obtained from Mr. Conner Motlow. Cumberland Springs Dam is a concrete structure that was built after World War I by Mr. Conner Motlow's father. The first structure was constructed without buttresses and failed during a large storm shortly after construction was completed. The existing structure was constructed of reinforced concrete arout 1921 using buggy axles, springs, and light railroad rails as reinforcement. The buttresses were constructed after the main dam was completed but were tied in to the dam with reinforcement. The top of the dam is 2 feet wide and the base is 10 feet wide. The base of the dam way keyed into rock several feet deep. The original constructed height of the dam was reported to be 33 feet. The concrete mix was reported to be a 2-2-2 with local crushed limestone used for the aggregate. The water-cement ratio is unknown.

A penstock was later added to the dam to operate a grist mill and small generator that was located at the east abutment. Traces of the mill remain although the penstock has been sealed with concrete.

A fish ladder was also attached to the downstream side of the dam near the east abutment. The fish ladder was destroyed by blasting and the concrete debris was left immediately below the dam.

During the second World War, the dam was taken over by the army and used for recreation and training purposes. A ledge of rock was blown off upstream from the dam causing an increase in the flow of the springs in the abutments. These springs were reported to have originally appeared over a long period of time.

The dam was repaired in 1976 by guniting portions of both the upstream and downstream faces of the dam. A light coating of gunite was observed.

DAM. Cumberland Springs Dam is 192.0 feet long and is 25 feet high above the foundation sill between the buttresses. The dam has six buttresses attached to the downstream face that reinforce the dam. The dam has a four foot steel walkway across the top. The longitudinal alignment is straight in a northwest-southeast orientation. Horizontal surface cracks were observed in both buttresses and dam. No vertical surface cracks were observed. The surface of both buttress and dam have considerable weathering with aggregate exposed in many places. The buttresses show considerably more weather than the dam with cracks along the outside edges.

Only 2 feet of the upstream side of the dam was exposed above the waterline. No surface cracks or other deficiencies were observed on this side.

No surface cracks or other deficiencies were observed on this side.

The downstream side of the dam has cracks as much as 6 inches deep. A horizontal surface crack extending practically the length of the dam is believed to be a cold joint. This crack or cold joint is approximately 10 feet above the foundation sill, and has opened as much as 6 to 8 inches in depth.

For the purpose of this report the buttresses are numbered 1 through 6 with Buttress No. 1 on the southeast side. Buttress No. 1 is the largest buttress and is approximately 5 feet in width and extends outward 25 feet the other 5 buttresses vary from 2 to 3 feet in width and extend out in varying lengths from 20 feet to 15 feet. In the bays between buttresses no. 1-2 and 2-3, there are seeps along the foundation sill of the dam. These seeps are red in color and have an oily sheen.

No severe erosion was observed at either abutment, but both abutments have many large springs. One area of rock at the west abutment has a large accumulation of accretions (tufa). Flowing springs were observed for some distance below the dam.

Cumberland Springs Dam does not have a service spillway. The emergency spillway has an ogee shape and is 136 feet long and 1.8 feet deep. Flows exceeding the capacity of the spillway flow across the top of the dam through 10 openings formed by the supports for the steel walkway. The crest of the spillway has been shaped but the face of the dam falls sharply. Low flows tend to follow the shape of the face but is anticipated that during large flows the nape would pull away from the face of the dam, resulting in negative pressure at the downstream face and causing the plunge pool to deepen and further undermine the buttresses. In 1977, Mr. Motlow reported that a 5.5 inch rain occurring within 2 hours caused a flood flow above the top of the dam but it did not cover the walkway.

There is a rectangular opening in the downstream face of the spillway for the drawdown pipe. The gate for the drawdown pipe has been inoperable several years. A 3 inch pipe extends from the bottom of the drawdown opening that was reported to have been installed by the Tennessee Fish & Wildlife Agency to sample oxygen levels in the lake. The valve for the system has been removed and the system plugged.

CONCLUSIONS. The limestone use for construction is embedded with shale and chert and the shale is leaching possibly causing the reddish oily sheen seen in the seepage between bays 1-2 and 2-3. The shale and chert has not bonded well with the cement causing spaulding and cracking and possibly the look of excessive weathering on the buttresses. The buttresses are in a process of being undermined by the deepening of the plunge pool and water action. Static stability of the structure cannot be determined from observation, but the dam has been standing approximately 60 years and has been overtopped in recent years without stress.

RECOMMENDATIONS. It is recommended that the leak in the east end wall be stopped. The undermined foundations of the buttresses should be repaired and protection should be provided to prevent future undermining of the buttresses. Open construction joints and the weather surface of the abutments should be repaired to prevent further deterioration. A weir should be installed downstream to monitor the flows from the abutments so that a sudden large increase in this flow could be determined quickly and downstream residents alerted to a possible dam failure. Emergency assistance should be obtained to design repairs to the structure.

Wm. E. Bush

Wm. E. Bush, P.E.
Civil & Water Resource Division

CUMBERLAND SPRINGS DAM
INSPECTION REPORT

INTRODUCTION. This report presents the results of an inspection of the Cumberland Springs Dam made on 13 May 1981. The dam is located on Hurricane Creek in the northeastern part of Moore County, Tennessee about three miles west of Tullahoma. It is a concrete dam 30.5 feet high impounding a maximum of 28.7 acre-feet of water. It was built in 1921 by the Motlow Brothers with hired labor, without formal engineering plans, using a quarry downstream from the dam site. The first dam was washed out in its first year and was rebuilt as a buttressed dam with an ogee overflow spillway. The elevation of the top of the dam is 1001.8, and that of the spillway is 999.9. The pool contains 9.2 acres at normal stage and 9.8 acres maximum. The crest of the dam is 163 feet long and two feet wide, becoming about 4 four feet wide at the right (west) abutment. Water in the lake comes largely from sets of springs. The reservoir banks are heavily wooded and vine covered. The pool water is fairly clear. It is understood that sediment has accumulated at the upper end of the pool to a depth of about 10 feet.

GEOLOGY. The geology of the site is shown on the Cumberland Springs quadrangle published by the Tennessee Geological Survey. The dam rests on a thin-bedded, flat-lying limestone with shale interbeds and chert veins, belonging to the Fort Payne Formation. This is an usually highly chertified Limestone of lower Mississippi age. The dam is located in the lower part of the formation, where there is less chertification and shale interbeds that increase in frequency as the base of the formation is approached. The bottom member of the Fort Payne is the Moore Shale, which is about seven feet thick. The top of this shale may be outcropping at the weir, about 400 feet below the dam. This shale gives an odor of petroleum when rubbed vigorously, and probably contains sulphur. The limestone is highly soluble, for a Paleozoic Limestone, as indicated by the widespread deposits of tufa along the right abutment. The aggregate in the concrete, as seen from blocks of the old, washed out dam, contains considerable amounts of chert, both as veins in the limestone fragments and as aggregate particles. Very little chert was seen in the bedrock in place.

The overlying Cathys and Leipers limestone outcrop behind the abutments and do not affect the dam. The underlying Chattanooga Shale is at an undetermined distance beneath the dam, and it with the Moore shale member of the Fort Payne, give reasonable assurance that there are no cavernous solution channels under the dam.

The major system strikes approximately east and west. The main joint system is at right angles to this. The solution channels generally follow the joint. The major joints are at about 30° angles to the dam, which runs about N60°W.

LEFT ABUTMENT. Just upstream from the dam, the abutment is protected with splashed concrete. The abutment itself rises about 5 feet above the pool, then slopes gently back from the dam for several hundred feet befor rising as a high ridge. Six springs come out of small solution channels within the first 50 feet below the dam. These are located between the base of the abutment and about 15 feet below the top of the dam.

Another large spring is flowing about halfway up the abutment face, about 100 feet downstream and still another at the base of the abutment about 20 feet further downstream. The abutment downstream is a nearly vertical face of flaggy limestone rising about 25 feet from the creek level, then sloping back gently.

A fish ladder had been built at the left abutment. This was removed and its remains can be seen about 50 feet below the dam at the foot of the abutment as a heap of concrete fragments. A concrete wall was built against the dam, at the abutment, and a mill was constructed here, set into the abutment. Two springs are coming out of the concrete in this wall, one about 5 to 7 feet below the walkway, and the other about 20 feet below. Another comes out at the top of a vertical concrete beam cast against the wall, about 15 feet below the walkway. The walkway is about 2 feet above the top of the dam. Steel reinforcement and an old steel wheel, along with a vertical and a horizontal concrete beam, both well weathered, are all that remain of the mill.

CUTOFF. A cutoff trench was cut along the base of the dam, according to Mr. Conner Motlow. The width of the base is 10 feet. No grouting has been done. The cutoff seems to be effective, as no boils were seen downstream. The end walls were keyed into rock at the abutment. There is considerable leakage around the left abutment, but the water is clear.

END WALLS. The end walls of the dam are keyed into rock and supported by buttresses at varying intervals. The buttresses are badly weathered. The weathering is less in the buttresses nearest the right abutment.

Weathering extends well back in the construction joints, about 10 feet above the base of the dam. These joints are open some 10 to 15 feet. The buttresses are undermined. Iron stained water was noted between the first and second buttresses west of the spillway, and also between the second and third The upstream faces have been gunited and are in good shape. The concrete in the dam used crushed limestone aggregate. According to Mr. Motlow, a 2:2:2 (cementfine aggregate-coarse aggregate) mix was used. The water--cement ratio is not known. Judging from chunks of concrete washed downstream from the first dam, the maximum size of aggregate is about 6 inches. The aggregate includes a significant quantities of chert.

The rock at the base of the buttresses west of the spillway was shale. This shale is hard, well cemented, limey, and does not slake. Some slaking shale was noted downstream.

SPILLWAY. The spillway has an ogee shape, but is stretched vertically from the usual ogee section. An outfall tunnel at the base is rounded at the discharge end. The entire face of the spillway has been covered with mesh-reinforced gunite, placed in the "70's". The gunite appears to be in very good condition. The spillway has been undermined at the base. It is understood that the gate controlling the outfall was put into working shape, but that it has not been used recently.

RIGHT ABUTMENT. The right abutment rises from the pool gradually to a height about ten feet above water, then flattens for a considerable distance, beyond which is a high hill. Below the dam, a rock ledge extends almost to the spillway section. Trees, mainly 4 to 6 inch in diameter with some up to 12 inches, are growing here. Near the base of the abutment and on into the stream, are 15 to 20 foot chunks of concrete from the old dam. Some of the axels used for reinforcement are protruding from the concrete. Below the dam the abutment slopes about 1 on 1 to 2 on 1. The rock is coated with tufa. About 75 feet below the dam a large stream, discharging several cfs, is flowing out of a solution channel in the rock. A considerable amount of tufa has been deposited here. Two small pipes have been placed in the rock (about 1.5 inches in diameter) and both are flowing. About 300 feet downstream a stream, probably spring-fed, is flowing off the abutment hill. The limestone here lies in flat sections about 0.5 to 2 inches thick.

DOWNSTREAM AREA. About 400 feet downstream, a weir with a square opening in the center crosses the stream. The concrete in the weir is badly weathered. This rock is very shaley. In the valley, about 200 feet downstream, one house is situated in the bottom, a second about five feet above the bottom, and two more about ten feet above.

RECOMMENDATIONS. This dam has been standing for a long time, and probably does not constitute any immediate hazard although it is difficult to assess the hazard with any assurance, knowing no more of the reinforcement and condition of the rock under the dam than is presently known. While the limestone must be considered as soluble from a geological point of view, the solution is slow over a period of 50 to 100 years. One cause for concern is the presence of sulfer-bearing, organic shale in the limestone. This in the aggregate, can act on the concrete and is probably one cause of the severe deterioration noted. In the rock below the dam, the bond between thin layers of rock can be weakened, and possibly, in conjunction with the undermining of the buttresses, lead to a sliding failure.

We recommend that the leak in the east end wall be repaired. We recommend that the undermined sections of the buttresses and spillway be repaired, possibly by grouting and placing of large rock fragments downstream to break up the energy of the water and to mitigate future undermining. We recommend that the open construction joints and crumbled sections of the buttresses be repaired. Finally, we recommend that a weir plate be placed in the weir downstream from the dam and monitored at least every two months. Engineering assistance should be obtained if any sudden large increase in flow in the weir occurs.

F. H. Kellogg, P.E.
Kellogg Engineering

APPENDIX E

HYDRAULIC AND HYDROLOGIC DATA

HYDRAULICS AND HYDROLOGIC CALCULATIONS

Cumberland Springs Dam is located in Moore County, Tennessee. The present land use is estimated to be 75 percent woodland and 25 percent openland. The soil is predominantly Mount View-Dickson-Guthrie and is classified as a "C" soil. The runoff curve number was calculated to be 71 AMC II.

The Cumberland Springs Dam is a small size, high hazard potential dam. As such it is required to pass the ½ PMF without overtopping. Using the U.S. Weather Service TP-40, the 6-hour PMP was estimated to be 29.2 inches yielding 24.82 inches runoff (RCN 71 AMC II). The ½ PMF which is derived from the Probable Maximum Precipitation was routed with a 12.41 inch runoff (RCN 71 AMC II).

The total inflow into the reservoir is about 2411 acre-feet with a maximum peak of 15016 cfs. Cumberland Springs reservoir has a maximum storage from the crest of the spillway to the top of the dam of 15.8 acre-feet and a maximum spillway discharge rate of 277 cfs. The impoundment is insufficient to safely pass the ½ PMF and would overtop the dam a maximum of 7.0 feet with flows lasting for 6 hours.

The 6-hour, 100-year flood containing 5.2 inches precipitation was routed through the dam using a RCN of 86 AMC III. This produced a runoff of 3.65 inches and a routed peak discharge of 4555 cfs. Cumberland Springs Dam overtopped with a maximum of 3.4 feet with flows lasting for 5 hours.

The inflow hydrograph was calculated by methods contained in Section 4, Chapter 21, of the SCS National Engineering Handbook. Weir constants in the formula $Q=CLH^{3/2}$ were found in King and Brater "Handbook of Hydraulics", fifth edition. The routing equation used was:

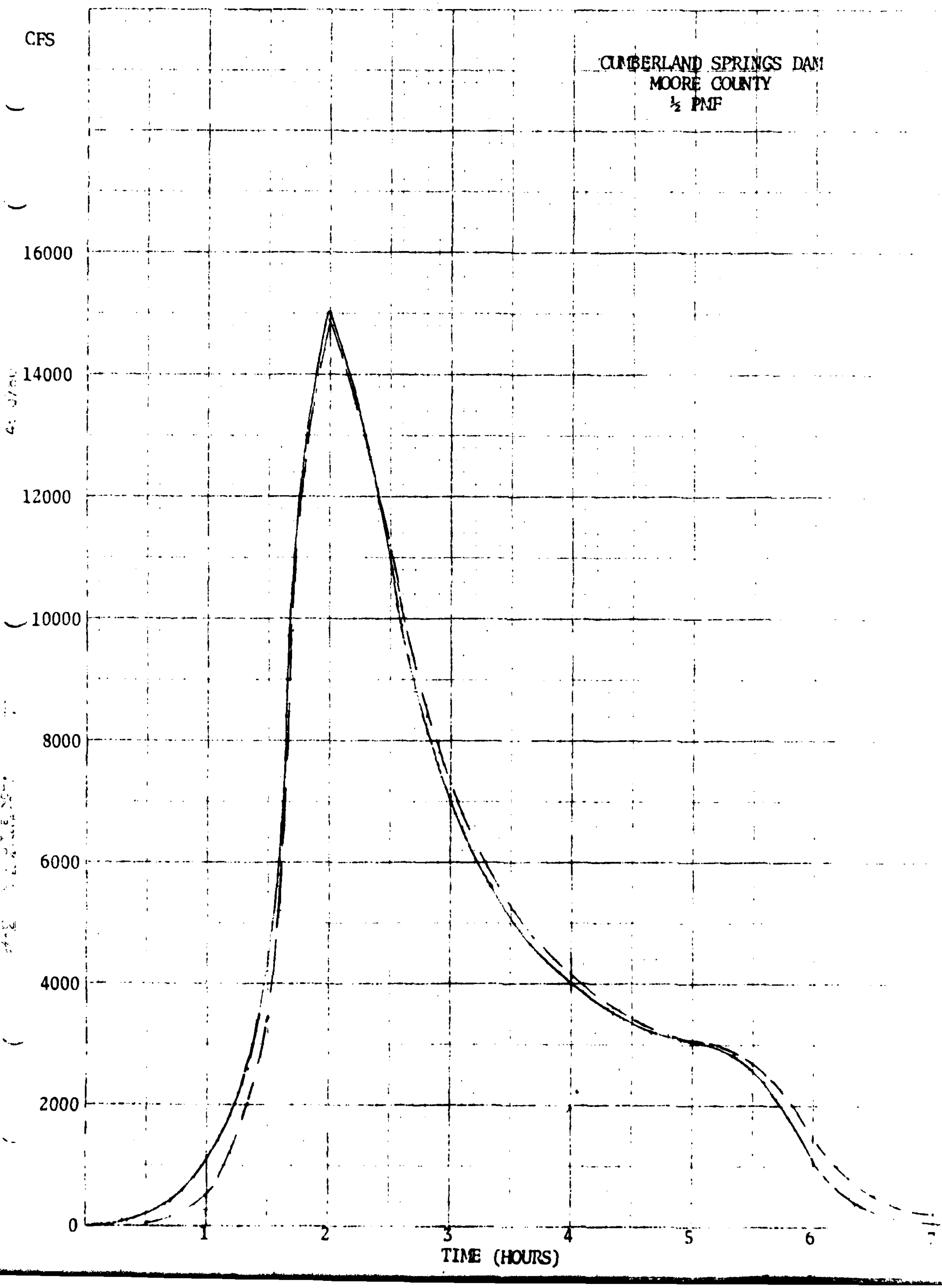
$$I_1 + I_2 + \left(\frac{2S_1}{\Delta t} - O_1\right) = \left(\frac{2S_2}{\Delta t} + O_2\right) .$$

Basic Engineering Data was obtained from the following sources: Engineering surveys of the impoundment structure; U.S. Geologic Survey Topographic Maps; Aerial photographs: USDA Soil Conservation Service Soil Survey Maps; Rainfall Data and Hazard Classification from the Tennessee Division of Water Resources.

HYDRAULIC AND HYDROLOGIC SUMMARY

Frequency of Occurrence	Duration	Antecedent Moisture Condition II	III
100-year	6-hour	Will Overtop 2.5 feet for 5 hours	Will Overtop 3.4 feet for 5 hours
100-year	10-day	---	---
½ PMF[1]	6-hour	Will Overtop 7.0 feet for 6 hours	Will Overtop 7.3 feet for 6 hours +
PMF	6-hour	Will Overtop 9.9 feet for 6 hours +	Will Overtop 10.2 feet for 6 hours +

[1]Probable Maximum Flood


CFS
CUMBERLAND SPRINGS DAM
MOORE COUNTY
½ PMF
16000
14000
12000
10000
8000
6000
4000
2000
0
1
2
3
4
5
6
TIME (HOURS)

NAME OF DAM =CUMBERLAND

STORM=1 2 PMF, 6 HOURS, AMC [illegible]
TIME INCREMENT IN HOURS = 0.[illegible]

TIME	[illegible]	[illegible]	[illegible]	[illegible]
0	0	0	0	[illegible]
0.10	20	[illegible]	[illegible]	
[illegible]	40	[illegible]	[illegible]	[illegible]
[illegible]	80	19[illegible]	[illegible]	
0.4[illegible]	150	41[illegible]	136	
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0.60	300	114[illegible]	[illegible]	[illegible]
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0.80	600	23[illegible]	[illegible]75	[illegible]
[illegible]	[illegible]00	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]14	41[illegible]	[illegible]	[illegible]
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1.20	1900	61[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	55[illegible]
3.50	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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6.40	350	4631	5092	630
6.50	300	4239	5281	521
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6.70	175	3534	4249	358
6.80	125	3236	3834	295
6.90	100	2956	3461	251
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7.50	[illegible]	177	1950	[illegible]
7.60	[illegible]	[illegible]	1776	[illegible]
7.70	0	1485	1620	[illegible]

½ PMF, 6 HOURS, AMC II

HYDROGRAPH COMPUTATION

DATE ____
COMPUTED BY ____
CHECKED BY ____

Project - Cumberland Springs Dam

DR. AREA 3.64 SQ. MI. STRUCTURE CLASS ____

T_c 0.88 HR. STORM DURATION ____ HR.

POINT RAINFALL 16.47 IN.

ADJUSTED RAINFALL:

AREAL FACTOR - IN. ____

DURATION FACTOR - IN. ____

RUNOFF CURVE NO. 71

Q 12.41 IN.

HYDROGRAPH FAMILY NO. 2

COMPUTED T_p 0.616 HR.

T_o 5.3 HR.

(T_o/T_p) COMPUTED 8.60 ; USED 10

REVISED T_p 0.53

$q_p = \frac{484A}{REV.\ T_p}$ = 3324.1 CFS.

$(Q)q_p$ = 41251.78 CFS.

t(COLUMN) = (t/T_p) REV. T_p q(COLUMN) = $(q_c/q_p)(Q)(q_p)$

Q(COLUMN) = $(Q_t/Q)Q$

	$t=(t/T_p)$ Rev. T_p	$q=(q_c/q_p)(Q)(q_p)$	$Q_t=(Q_t/Q)Q$
	t HOURS	q CFS	Q INCHES
1	0	0	0
2	.33	83	
3	.66	371	
4	1.00	1114	
5	1.33	2599	
6	1.66	9735	
7	2.00	15016	
8	2.33	12664	
9	2.67	9323	
10	3.00	7095	
11	3.33	5610	
12	3.67	4661	
13	4.00	4001	
14	4.34	3506	
15	4.67	3218	
16	5.00	3053	
17	5.34	2846	
18	5.67	2186	
19	6.01	1031	
20	6.34	371	
21	6.67	165	
22	7.01	83	
23	7.34	41	
24	7.67	0	
25		88772	
26	check: $\frac{88772\ (.034)}{645\ (3.64)}$ = 12.85"		
27			
28			+4% ok
29			
30			
31			
32			
33			
34			

Winsett-Simmonds, Consterdine & Associates, Inc.
821 SOUTH BARKSDALE STREET P O BOX 4041 MEMPHIS, TENNESSEE 38104
TELEPHONE 901 274-8480
Systems Engineers

```
*************************************
POWER CURVE FIT EQUATION
*************************************

 PROJECT = [illegible]

 Y=A*X^B

 A = 1.83[illegible]E-0[illegible]

 B = [illegible]E+00

 COEF. OF DETERMINATION= 0.[illegible]

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

FOR X= [illegible].00000     THEN PROJECTED Y= [illegible]
FOR X= [illegible].00000     THEN PROJECTED Y= [illegible]36.28891
FOR X= [illegible].00000     THEN PROJECTED Y= [illegible]30.91[illegible]68
FOR X= [illegible]1.00000    THEN PROJECTED Y= 1302.822[illegible]
FOR X= [illegible]356.00000  THEN PROJECTED Y= 1[illegible]65.9[illegible]
FOR X= [illegible]22.00000   THEN PROJECTED Y= [illegible].4[illegible]
FOR X= [illegible].00000     THEN PROJECTED Y= [illegible]
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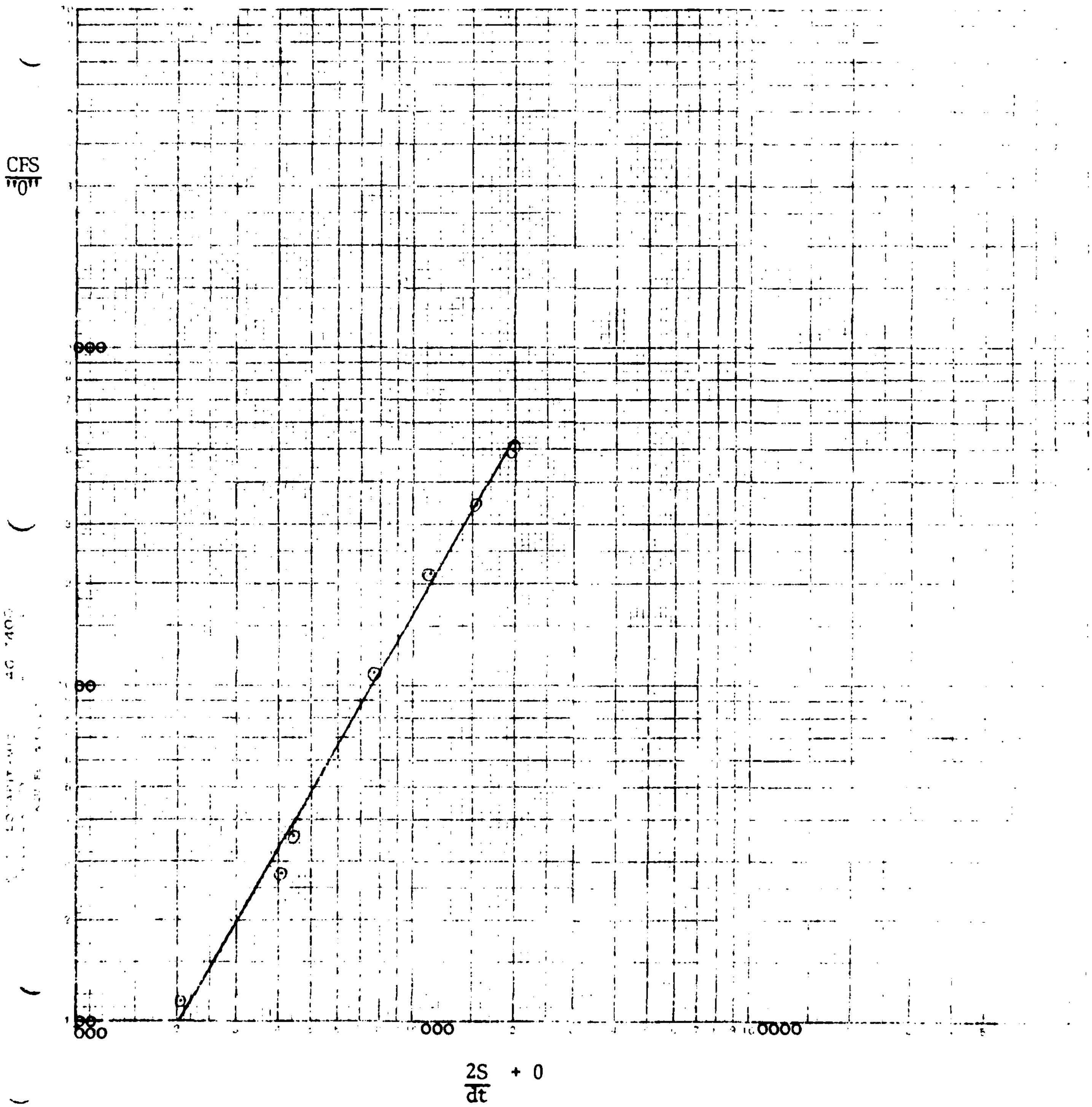
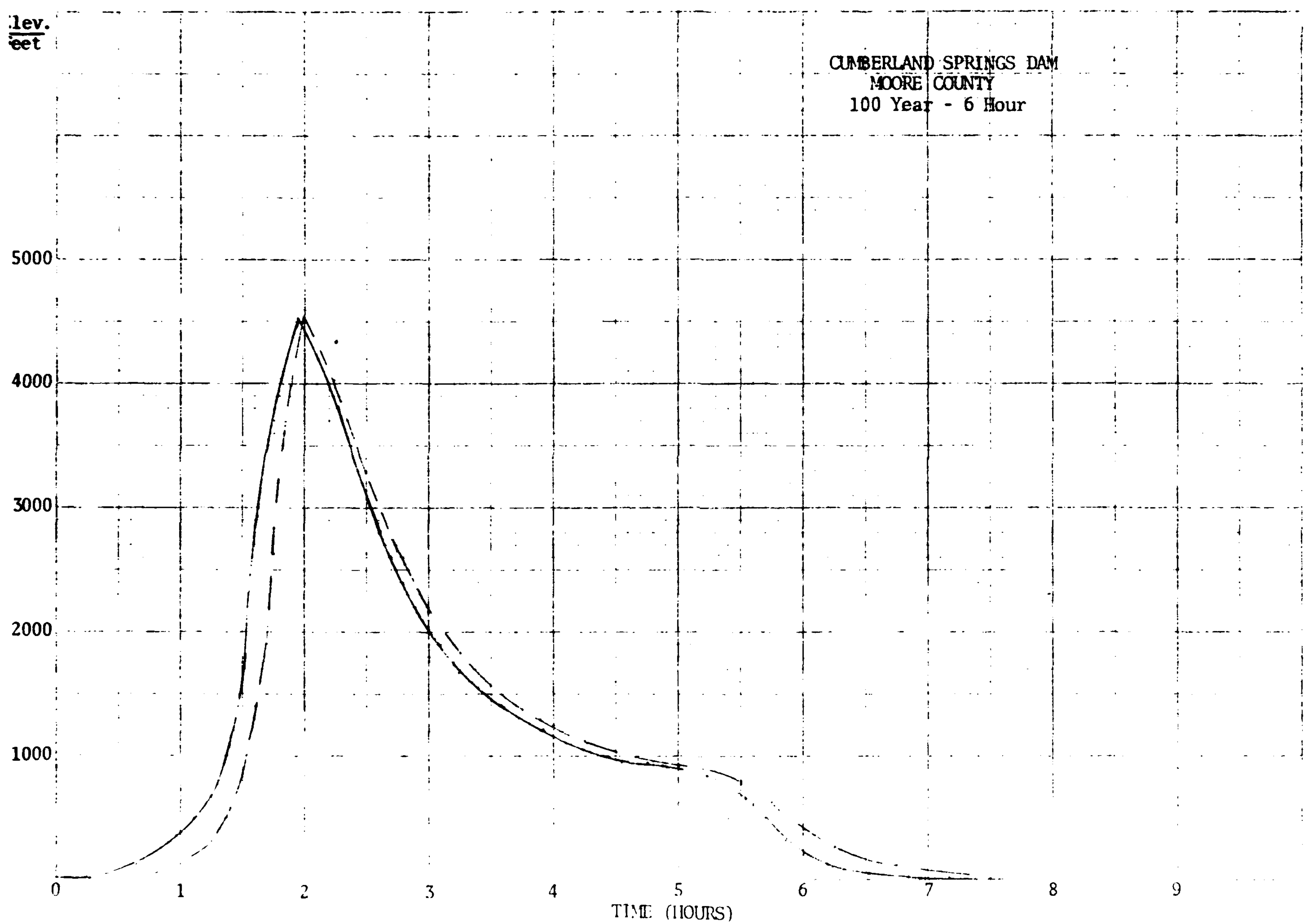
CUMBERLAND SPRINGS DAM
STORAGE INDICATION CURVE




CUMBERLAND SPRINGS DAM
MOORE COUNTY
100 Year - 6 Hour
Elev.
Feet
5000
4000
3000
2000
1000
0
1
2
3
4
5
6
7
8
9
TIME (HOURS)

NAME OF DAM =[illegible]

STORM [illegible] YEAR, [illegible] HOURS, AMC [illegible]
TIME INCREMENT IN HOURS = 0.[illegible]

TIME	[illegible] (CFS)	25 [illegible]	2[illegible]	[illegible]
0	0	0	0	[illegible]
0.25	20	[illegible]	20	0
0.5[illegible]	80	11[illegible]	11[illegible]	[illegible]
0.75	200	331	190	[illegible]0
1.00	375	686	806	[illegible]
1.25	675	11[illegible]	17[illegible]6	[illegible]
1.50	1600	1686	[illegible]	[illegible]
1.[illegible]5	[illegible]700	172[illegible]	[illegible]9[illegible]6	[illegible]
2.[illegible]	[illegible]	8[illegible]	[illegible]9[illegible]6	[illegible]
2.2[illegible]	3850	11[illegible]	[illegible]6	[illegible]
2.50	[illegible]100	148[illegible]	[illegible]	[illegible]
2.[illegible]5	[illegible]450	171[illegible]	[illegible]6	[illegible]
3.00	2090	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]700	18[illegible]	[illegible]	[illegible]
[illegible]	[illegible]450	18[illegible]	[illegible]	[illegible]

4.00	1100	182[illegible]	[illegible]	[illegible]
4.25	1050	17[illegible]	[illegible]28	[illegible]
4.50	1000	1764	3724	[illegible]
4.75	925	17[illegible]	[illegible]	460
5.00	900	1717	3562	[illegible]
5.25	825	1697	3412	605
5.50	700	1644	3215	788
5.75	450	1525	[illegible]	[illegible]
6.00	225	1330	2204	[illegible]
6.25	100	1095	[illegible]55	[illegible]
6.50	55	880	1250	[illegible]
6.75	30	720	973	12[illegible]
7.00	20	6[illegible]	779	[illegible]
7.25	10	509	635	[illegible]
7.50	0	426	5[illegible]	[illegible]

100 YEAR 6 HOURS AMC III

HYDROGRAPH COMPUTATION

DATE ____
COMPUTED BY ____
CHECKED BY ____

Project - Cumberland Springs Dam

DR. AREA 3.64 SQ. MI. STRUCTURE CLASS ____

T_c 0.88 HR. STORM DURATION ____ HR.

POINT RAINFALL 5.2 IN.

ADJUSTED RAINFALL:

AREAL FACTOR ____ IN. ____

DURATION FACTOR ____ IN. ____

RUNOFF CURVE NO. 86

Q 3.65 IN.

HYDROGRAPH FAMILY NO. 2

COMPUTED T_p 0.616 HR.

T_o 5.18 HR.

T_o/T_p

COMPUTED 8.41 USED 10

REVISED T_p 0.518

$q_p = \frac{484A}{REV.\ T_p}$ = 3401.1 CFS.

$(Q)q_p$ = 12413.95 CFS.

t COLUMN = (t/T_p) REV. T_p q COLUMN = $(q_c/q_p)(Q)q_p$

Q COLUMN = Q_t Q/Q

	t (HOURS)	q (CFS)	Q (INCHES)
	(t/T_p) Rev. T_p	$(q_c/q_p)(Q)q_p$	Q_t/Q Q
1	0	0	0
2	.32	25	
3	.65	112	
4	.97	335	
5	1.30	782	
6	1.63	2930	
7	1.95	4519	
8	2.28	3811	
9	2.61	2806	
10	2.93	2135	
11	3.26	1688	
12	3.58	1403	
13	3.91	1204	
14	4.24	1055	
15	4.56	968	
16	4.89	919	
17	5.22	857	
18	5.54	658	
19	5.87	310	
20	6.20	112	
21	6.52	50	
22	6.85	25	
23	7.17	12	
24	7.50	0	
25		26716	
26			
27	check:	26716 (.32)	= 3.64"
28		645 (3.64)	
29			ok
30			
31			
32			
33			
34			

Winsett Simmonds, Consterdine & Associates, Inc
921 SOUTH BARKSDALE STREET P.O. BOX 40041 MEMPHIS, TENNESSEE 38104
TELEPHONE 901 276-6400
Systems Engineers

```
POWER CURVE FIT EQUATION
************************

 PROJECT = CUMBERLAND DAM

 Y=A*X^B

 A = [illegible]

 B = .5[illegible]17E+00

 COEF. OF DETERMINATION= 0.9[illegible]

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

FOR X= 833.00000  THEN PROJECTED Y= 106.5[illegible]

FOR X= 1807.00000    THEN PROJECTED Y= [illegible]

FOR X= 2605.00000    THEN PROJECTED Y= [illegible].[illegible]3592

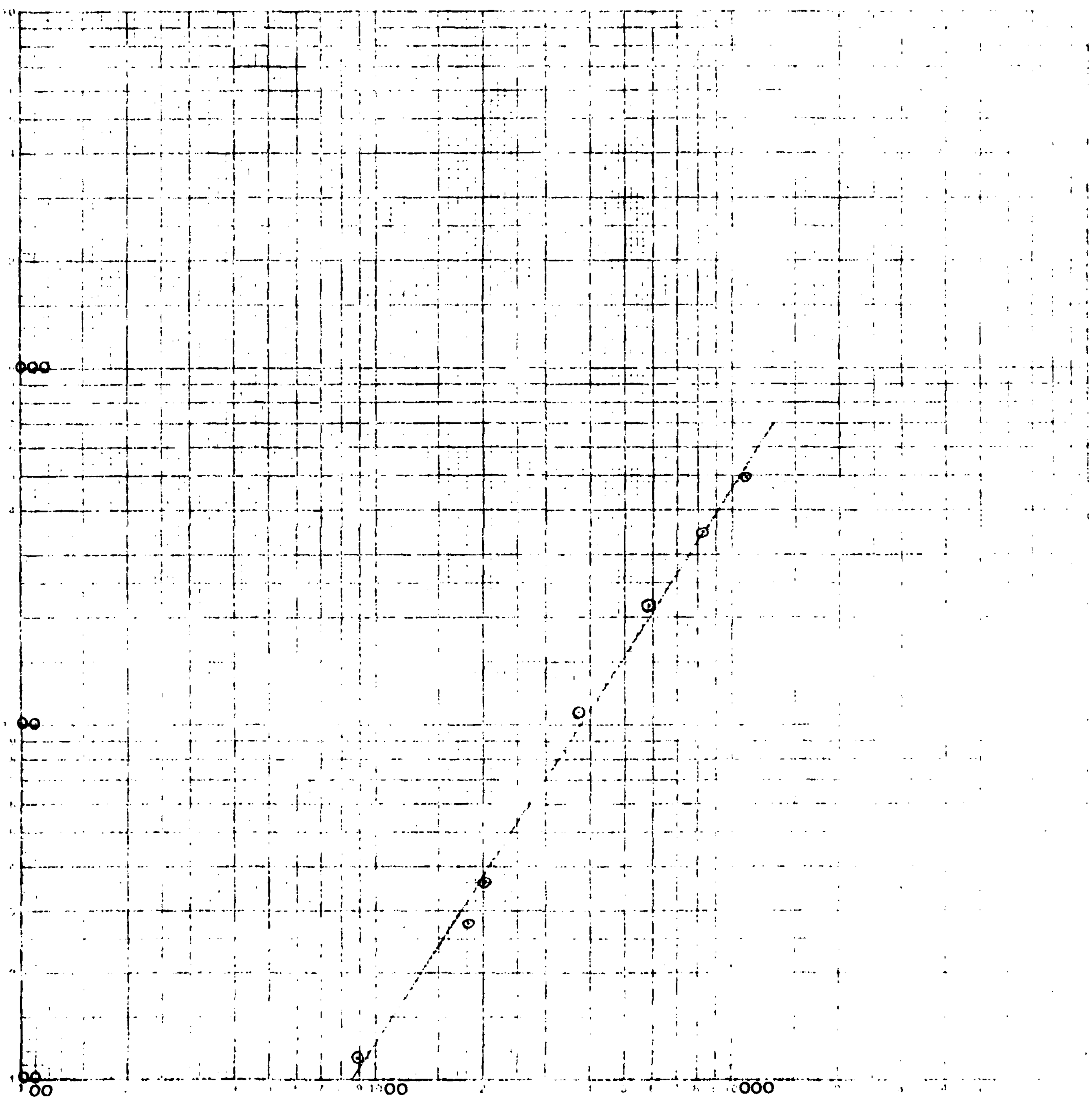
FOR X= 3738.00000    THEN PROJECTED Y= [illegible].25588

FOR X= 5[illegible]8.00000    THEN PROJECTED Y= [illegible].[illegible]220[illegible]

FOR X= [illegible]2.00000    THEN PROJECTED Y= [illegible].001[illegible]

FOR X= [illegible]    THEN PROJECTED Y= 1303.7564[illegible]
```

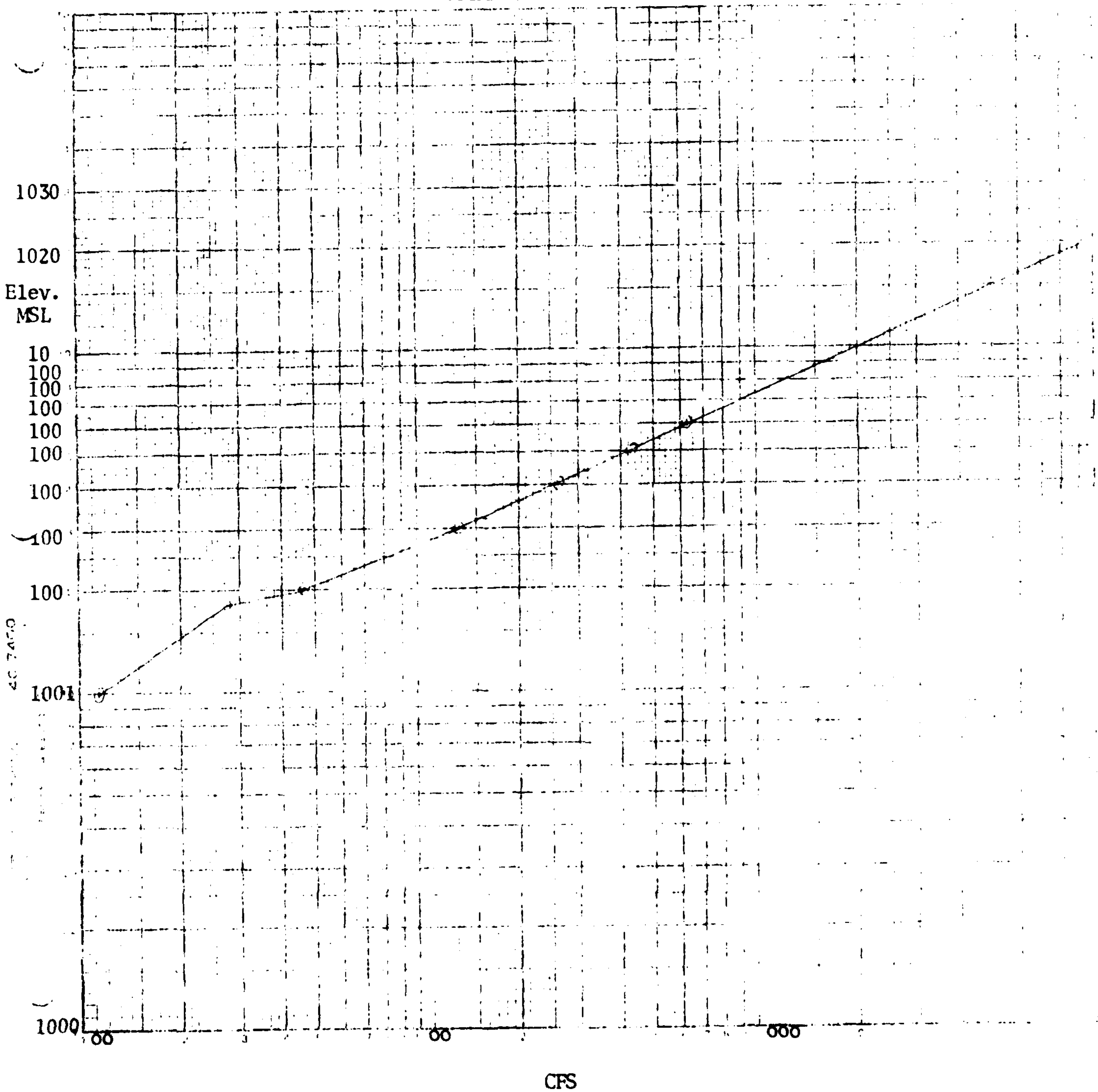
CUMBERLAND SPRINGS DAM

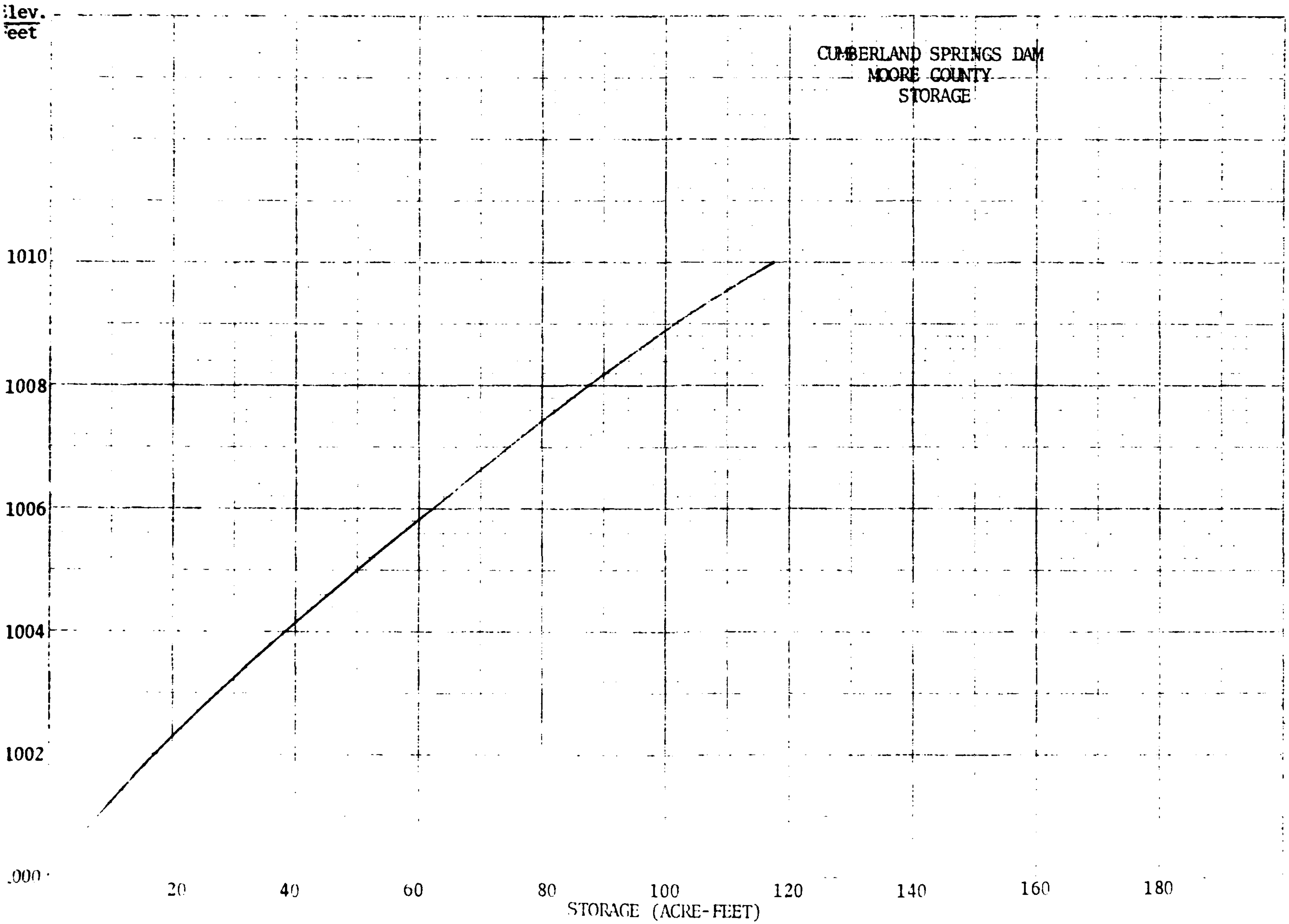


$$\frac{2S}{dt} + 0$$

dt = 0.25

CUMBERLAND SPRINGS DAM
TOTAL CFS DISCHARGE




CUMBERLAND SPRINGS DAM
MOORE COUNTY
STORAGE
Elev.
Feet
1010
1008
1006
1004
1002
1000
20
40
60
80
100
120
140
160
180
STORAGE (ACRE-FEET)

CUMBERLAND SPRINGS DAM

Spillway Discharge

L = 36'
C = 3.19

$Q = CLH^{3/2}$

Elev.	H	$H^{3/2}$	Q
1000	0	0	0
1001	1	1	114.8
1001.8	1.8	2.41	276.8
1002	2	2.83	325.0
1003	3	5.20	597.2
1004	4	8.00	918.7
1005	5	11.18	1283.9
1006	6	14.70	1688.1

Overtop Discharge

C = 3.2

L = 14 + 12 + 10 + 11 + 12 + 12.5 + 11 + 9 + 15.5 = 119.0

Elev.	H	$H^{3/2}$	Q
1001.8	0	0	0
1002.0	.2	0.09	34.3
1003	1.2	1.31	498.8
1004	2.2	3.26	1241.4
1005	3.2	5.72	2178.2
1006	4.2	8.61	3278.7

Overland Flow Around Dam

n = 0.070 S = 0.0100 $V = (1.486/n)\ S^{1/2}R^{2/3}$

Elev.	L (ft)	R	A	V	Q
1001	0	0	0	0	0
1002	33	1.18	43.5	2.37	103.10
1003	50	1.52	85.0	2.81	238.85
1004	63	1.99	141.5	3.36	475.44
1005	80	2.37	213.0	3.77	803.01
1006	96	2.95	301.0	4.37	1315.37
1007	110	3.26	404.0	4.67	1886.68
1008	127	3.65	522.5	5.03	2628.18

Total Discharge

Elev.	Sply	Overflow Area	Overland Flow	Total
1000				0
1001	115			115
1001.8	277			277
1002.0	325	34	103	462
1003	597	499	239	1335
1004	919	1241	475	2535
1005	1688	3279	1315	6282

APPENDIX F

DAM INVENTORY DATA SHEET

ID NUMBERS STATE(ID): 647001 FEDERAL(FED ID): TN 12701

NAME(PROJECT): Cumberland Springs Lake Dam REGION(R): Middle

OWNER(S): Conner Motlow

ADDRESS: P. O. Box 155, Lynchburg, Tennessee 37352

TELEPHONE RESIDENCE: 759-7300 BUSINESS:

COUNTY: Moore QUAD: Cumberland Springs, 79SE

LOCATION LATITUDE: 35 ° 20 ' 25 ", LONGITUDE: 86 ° 17 '- 46 "

STREAM(SOURCE): Hurricane Creek RIVER MILE: BASIN: 27A

PURPOSE OF DAM: Recreation YEAR COMPLETE: 1921

CONTRACTOR(CONT): Owner's father LOCATION: Lynchburg

ENGINEER(ENG): LOCATION:

TYPE OF DAM(TYC): Concrete SIZE CLASSIFICATION: Small

DOWNSTREAM HAZARD POTENTIAL CLASSIFICATION STATE(H) 1 FEDERAL(FH) High

CERTIFICATE EXPIRATION DATE(EXP DATE):

STRUCTURAL HEIGHT(SHT): 30.5 FEET, HYDRAULIC HEIGHT(HHT): 28.7 FEET

CREST LENGTH(LGTH): 163 FEET, CREST WIDTH(WDTH): 2 FEET

UPSTREAM SLOPE(U/S): app. vertical DOWNSTREAM SLOPE (D/S): app. vertical

POOL AREA NORMAL(NSURF): 9.2 ACRES, MAXIMUM(M/SURF): 9.8 ACRES

	ELEVATION(FEET MSL),		STORAGE CAPACITY(ACRE-FEET)
TOP OF DAM	(ELEV1) 1001.8	(TO/STR)	122.7
EMERGENCY SPILLWAY CREST	(ELEV2) 999.9	(EM/STR)	
NORMAL POOL	(ELEV3) 1000	(N/STR)	105.6
EMERGENCY SPILLWAY MATERIAL(ESM)	S	SIZE(SZ)	
SERVICE SPILLWAY MATERIAL(SSM)	Concrete	SIZE(SZ)	36'

DRAINAGE AREA(DA): 3.4 SQ. MILES, CURVE NUMBER(CN): AMCII

TIME OF CONCENTRATION(TC): HOURS, MAXIMUM 6-HR RAIN: INCHES

COMMENTS: INVENTORIED BY: Ramsey, Culbert DATE: 2/12/80

REVISED BY: DATE: D/S HAZARD BY: Same DATE: 2/12/80

OTHER NAME OF PROJECT: POOL AREAS OBTAINED BY: topo sheet

OTHER CONTACT AT DAM: PHONE:

DATA OBTAINED FROM: Files and field survey

EMER. SPIL. DESC.: 36' wide and 1.8' high (ogee-shaped)

SERV. SPIL. DESC.:

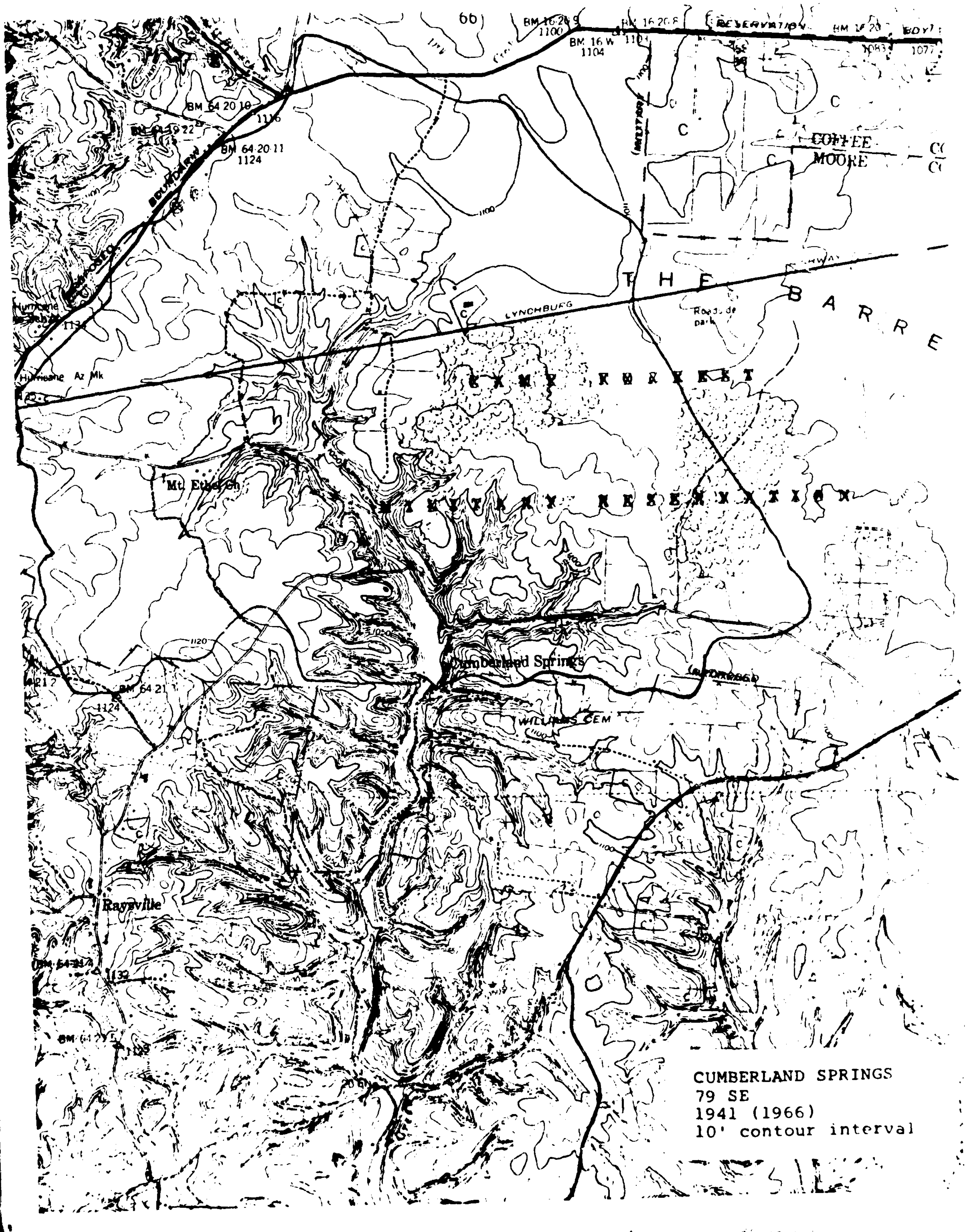
ELEVATIONS REF. TO: T.B.M. (W.S.) APPROX ELEV: 1000 FT MSL

DRAWDOWN DRAIN: MATERIAL: Unknown SIZE: ELEVATION:

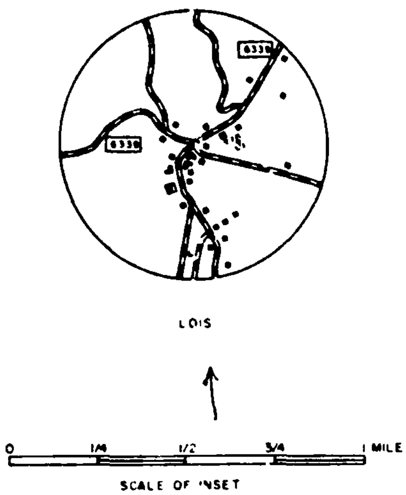
OTHER COMMENTS: Drawdown drain was inaccessible.

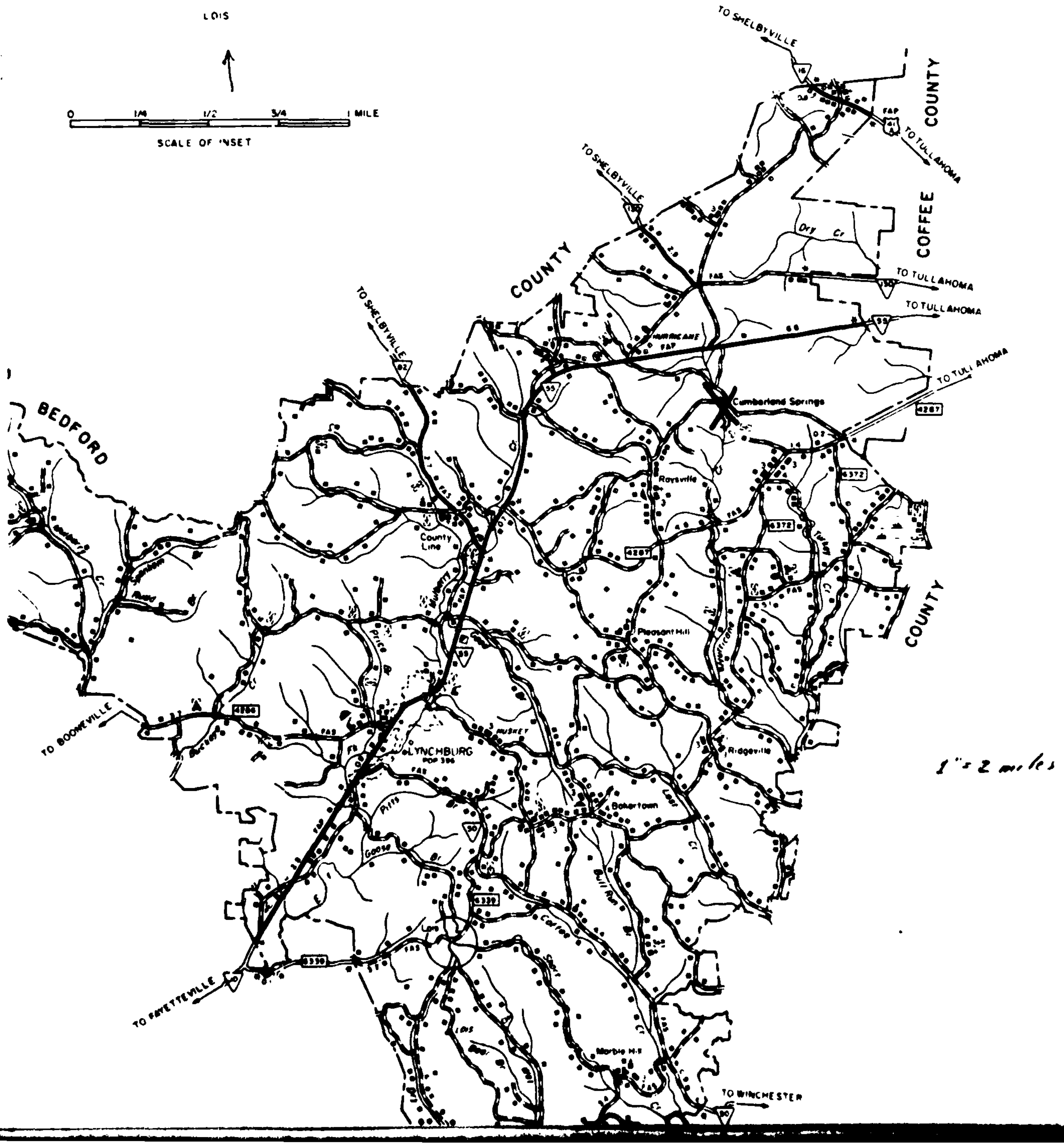
Lake was drained and dam was patched and grouted about two years ago.

Plans not available



CUMBERLAND SPRINGS
79 SE
1941 (1966)
10' contour interval


6330
6330
LOIS
0
1/4
1/2
3/4
1 MILE
SCALE OF INSET


TO SHELBYVILLE
TO TULLAHOMA
COFFEE
COUNTY
TO SHELBYVILLE
TO TULLAHOMA
TO TULLAHOMA
COUNTY
TO SHELBYVILLE
TO TULLAHOMA
Cumberland Springs
4287
BEDFORD
Raysville
6372
6372
County Line
Pleasant Hill
COUNTY
TO BOONEVILLE
4286
LYNCHBURG
POP 396
Ridgeville
Bakertown
6330
6330
Lois
TO FAYETTEVILLE
Marble Hill
TO WINCHESTER
1" = 2 miles

Check List
Visual Inspection of Earth Dams
Department of Conservation
Division of Water Resources

Name of Dam: [illegible] Springs Dam

County: Moore Date of Inspection: 2-12-80

ID # - State: 47001 Federal: ______

Type of Dam: Concrete

Hazard Category-Federal: High State: 1

Weather: Partly Cloudy Temperature: 35°F

Pool at Time of Inspection ______ (distance from crest)

Tailwater at Time of Inspection ______ (distance from stream bed)

Design/As Built Drawings Available: Yes ______ No x

Location: ______

Copy Obtained: Yes ______ No ______

Reviewed: Yes ______ No ______

Construction History Available: Yes X No ______

Location: File at TDWR - some verbal information obtained from owner [illegible] on construction of dam

Copy Obtained: Yes ______ No ✓

Reviewed: Yes ______ No ✓

Other Records and Reports Available: Yes ______ No x

Location: ______

Copy Obtained: Yes ______ No ______

Reviewed: Yes ______ No ______

Prior Incidents or Failures: Yes x No ______

Inspection Personnel and Affiliation:

[illegible] - TDWR

[illegible] - TDWR

I. Embankment

A. Crest

Description (1st inspection) Concrete crest. Walkway bridge over crest.

1. Longitudinal Alignment Linear

2. Longitudinal Surface Cracks None found

3. Transverse Surface Cracks None found

4. General Condition of Surface Crest of dam is in good condition.

5. Miscellaneous Crest of dam could not be adequately inspected without safety equipment.

B. Upstream Slope

1. Undesirable Growth or Debris N/A

1

2. Sloughing, Subsidence, or Depressions

~~None observed~~ Unknown

3. Slope Protection N/A

a. Condition of Riprap N/A

b. Durability of Individual Stones N/A

c. Adequacy of Slope Protection Against Waves and Runoff N/A

d. Gradation of Slope Protection - Localized Areas of Fine Material N/A

4. Surface Cracks ~~None noted on top of dam could not be adequately observed due to bridge structure~~ Unknown - upstream face submerged

C. Downstream Slope

1. Undesirable Growth or Debris N/A

2. Sloughing, Subsidence, or Depressions; Abnormal Bulges or Non-Uniformity *None observed*

3. Surface Cracks on Face of Slope *Several signs of* [illegible] *of concrete on downstream face. Some* [illegible] *repaired about 2 years ago. D/S buttress supports have suffered some scaling and* [illegible] *at edges of* [illegible] *concrete.*

4. Surface Cracks or Evidence of Heaving at Embankment Toe

5. Wet or Saturated Areas or Other Evidence of Seepage on Face of Slope; Evidence of "Piping" or "Boils" *Leak emerges from right end of D/S face near the top of the dam. Appears to be* [illegible] *along a construction joint*

6. Drainage System *None found*

7. Fill Contact with Outlet Structure *N/A*

8. Condition of Grass Slope Protection *N/A*

D. Abutments

1. Erosion of Contact of Embankment with Abutment from Surface Water Runoff, Upstream or Downstream _None, [illegible] [illegible] section eroded out [illegible] long ago and was repaired with concrete._

2. Springs or Indications of Seepage Along Contact of Embankment with the Abutments ~~[illegible]~~

3. Springs or Indications of Seepage in Areas a Short Distance Downstream of Embankment - Abutment Tie-in _[illegible] [illegible] of leakage from both rock abutments below dam. Left abutment started leaking during WWII after a rock ledge in the reservoir was blasted off by soldiers at the camp._

4

II. Area Downstream of Embankment, Including Channel

A. Localized Subsidence, Depressions, Sinkholes, Etc. ____

None

B. Evidence of "Piping", "Boils", or "Seepage" ____

None found, all leakage was from abutment [illegible]

C. Unusual Presence of Lush Growth, such as Swamp Grass, etc. None

D. Unusual Muddy Water in Downstream Channel ____

None

E. Sloughing or Erosion ____

None

F. Surface Cracks or Evidence of Heaving Beyond Embankment Toe None

G. Stability of Channel Sideslopes good, side slopes [illegible] earth

H. Condition of Channel Slope Protection N/A

I. Adequacy of Slope Protection Against Waves, Currents, and Surface Runoff N/A

J. Miscellaneous

K. Condition of Relief Wells, Drains, and Other Appurtenances N/A

L. Unusual Increase or Decrease in Discharge from Relief Wells N/A

III. Instrumentation

A. Monumentation/Surveys N/A

B. Observation Wells N/A

C. Weirs N/A

D. Piezometers N/A

E. Other

IV. Spillways

A. Service Spillway (Service/Emergency Combination Yes ✓ No __)

1. Intake Structure Condition ____________________

2. Outlet Structure Condition ____________________

3. Pipe Condition ____________________

4. Evidence of Leakage or Piping ____________________

5. General Remarks ____________________

B. Emergency Spillway

1. General Condition *Good condition, ~~[illegible]~~ ~~[illegible]~~ Appears that spillway was ~~[illegible]~~ resurfaced during maintenance work on the dam [illegible]*

2. Entrance Channel *N/A*

3. Control Section *Locate at crest of ogee-shaped weir.*

3. Exit Channel Spillway empties into large rock-bottomed channel below the dam.

4. Vegetative/Woody Cover None

5. Other Observations

9

V. Emergency Drawdown Facilities (if part of service spillway so state) Located at base of dam. Gate is ~~operated~~ operable. Believed to be 30" x 30" gate.

Are Facilities Operable: Yes ✓ No ____

Were Facilities Operated During Inspection: Yes ____ No ✓

Date Facilities Were Last Used About 1977

VI. Reservoir

A. Slopes Steep (estimated from surrounding topography)

B. Sedimentation Unknown

C. Turbidity Low

VII. Drainage Area

Description (for hydrologic analysis)

Mostly wooded area

A. Changes in Land Use None expected

VIII. Downstream Area (Stream)

A. Condition (obstructions, debris, etc.)

Small concrete weir dam about [illegible] feet downstream was buit by the WPA in 1940.

B. Slopes Approx. 0.4%

C. Approximate No. Homes, Population, and Distance D/S

Three houses located between 1 and 2 [illegible] D/S.

D. Other Hazards A county road located 2 miles D/S

IX. Miscellaneous

Incidents/Failures During WWII, soldiers blasted a rock ledge in the lake that created leaks from the D/S left abutment. The upper right abutment was washed out at one time and replaced with concrete.

Observed Geology of Area Base of dam is set into massive shale

X. Conclusions

1. Dam is structurally stable.

2. Spillway is

XI. Recommendations

Repair leak on upper portion of dam near right abutment.

Bob Ramsey
Regional Engineer

Chief Engineer

Photo Log

Photo No. 1 - Lake and dam from upstream left.

Photo No. 2 - Seepage from beneath concrete foundation at right abutment.

Photo No. 3 - Dam from downstream left.

Photo No. 4 - Downstream left abutment.

Photo No. 5 - Seepage at toe just right of center.

Photo No. 6 - Right abutment rock formation. (Notice leak in dam at top center of picture.)

Photo No. 7 - Top view of toe, right of center.

Photo No. 8 - Small dam downstream from main dam crest.

PHOTO NO. 1

PHOTO NO. 2

PHOTO NO. 3

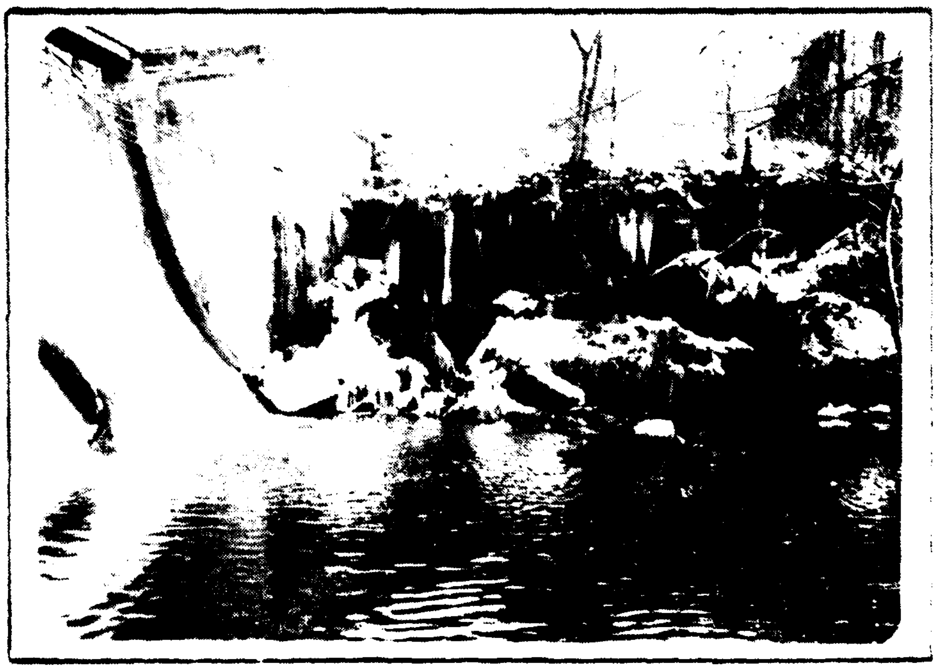


PHOTO NO. 4

AD-A108 465 TENNESSEE STATE DEPT OF CONSERVATION NASHVILLE DIV O--ETC F/G 13/13
NATIONAL PROGRAM OF INSPECTION OF NON-FEDERAL DAMS TENNESSEE. C--ETC(U)
SEP 81 W E BUSH DACW62-81-C-0056

UNCLASSIFIED NL

2 of 2

END
DATE FILMED
01-82
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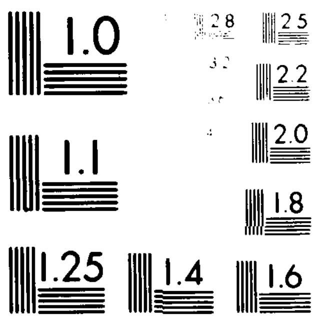

MICROCOPY RESOLUTION TEST CHART

PHOTO NO. 5

PHOTO NO. 6

PHOTO NO. 7

PHOTO NO. 8

ORNED-D 24 September 1980

MEMORANDUM FOR RECORD

SUBJECT: Trip Report Covering the Inspection of Cumberland Springs Dam Near Lynchburg, TN

1. On 8 September 1980, Mr. Bob Ramsey, Tennessee Department of Conservation, and Mr. James Gunnels, US Army Corps of Engineers, went to Lynchburg, Tennessee to make a cursory inspection of the Cumberland Springs Dam.

2. We were met at the Dam by the owner and representatives of the owner. Inclosed is a list of those in attendance.

3. The Dam, located outside Lynchburg, is a concrete, buttress type dam with an uncontrolled spillway and it was built in the early 1920's. The Dam was constructed and the area was developed as a recreation resort because of the presence of sulfur springs.

4. Originally the Dam was built without buttresses and during the first year of operation it washed out. The Dam was replaced one year later and this time buttresses were added. In the early 1940's the United States Army came in and took over the entire area for training purposes. In the upper reaches of the lake there was a rock ledge that overhung the water. One day a soldier jumped from this ledge and drowned. An Army officer then took explosives and blew this rock ledge off. When this happened the Dam started leaking around each abutment. According to Mr. Connor Motlow (the owner), the leakage has not increased since it originally started leaking. It is possible that some or all of this leakage around the abutments is due to spring water rather than from the lake. There are a lot of springs in this area. The lake was eventually turned back over to the original owner. Dye tests were conducted (sometime in the 1950's) at various points in the lake to try and determine if the abutment leaks were coming from the lake. None of these tests were successful. They could not tell if any of the dye came out the leaks. Leakage on the right abutment side is shown in photographs No. 1, 2, and 3. The left abutment side was not accessible. Leakage was viewed from the right downstream bank.

5. In 1976, the lake was unwatered and the upstream face of the Dam and the spillway were repaired by fastening wire mesh on the face and then spraying the face with Gunnite approximately 3 to 4 inches thick. It is not known if the abutment leakage stopped during this unwatering.

ORNED-D
SUBJECT: Trip Report Covering the Inspection of Cumberland Springs Dam Near Lynchburg, TN

6. The downstream face of the buttresses are experiencing spalls and deterioration, primarily due to the action of weather, i.e., freeze-thaw, but this appears to be only superficial. There are two small leaks in two bays between the buttresses (see photos no. 9 and 10). There are four houses downstream of the Dam that possibly could be flooded in the event the Dam ever did fail. However, these houses appear to be far enough downstream that the flooding would probably be slight, if any.

JAMES GUNNELS
Civil Engineer
Civil-Structural Section

CF:
Mr. Bob Ramsey HOOT/ED-D
Mr. Doug Clark
Mr. Tommy Armour H. GRAY/ED-D

Personnel in Attendance

Mr. Connor Motlow	Owner
Mr. Charles Manley	Jack Daniels Distillery
Mr. Doug Clark	Environmental Coordinator, Jack Daniels Distillery
Mr. Tommy Armour	Farmers Bank, Lynchburg, Tennessee
Mr. Carl Payne	Tennessee Game and Fish Commission
Mr. Bob Ramsey	Tennessee Department of Conservation
Mr. James Gunnels	US Army Corps of Engineers, Nashville

APPENDIX G

HAZARD POTENTIAL

AND

CONDITION CLASSIFICATION DEFINITIONS

DEPARTMENT OF THE ARMY

OFFICE OF THE CHIEF OF ENGINEERS

HAZARD POTENTIAL CLASSIFICATION*

Category	Loss of Life	Economic Loss
Low	None expected (No permanent structures for human habitation)	Minimal (Undeveloped to occasional structures or agriculture)
Significant	Few (No urban developments and no more than a small number of inhabitable structures)	Appreciable (Notable agriculture, industry or structures)
High	More than few	Excessive (Extensive community, industry or agriculture)

*U.S. Army Corps of Engineers, Recommended Guidelines for Safety Inspection of Dams.

TENNESSEE DEPARTMENT OF CONSERVATION

DIVISION OF WATER RESOURCES

DAMAGE POTENTIAL CATEGORY*

Category	Description
1.	Dams located where failure would probably result in any of the following: loss of human life; excessive economic loss due to damage of downstream properties; excessive economic loss, public damage to roads or any public or private utilities.
2.	Dams located in predominantly rural or agricultural areas where failure may damage downstream private or public property but such damage would be relatively minor and within the general financial capabilities of the dam owner. Public hazard or inconvenience due to loss of roads or any public or private utilities would be minor and of short duration. Chances of loss of human life would be possible but remote.
3.	Dams located in rural or agricultural areas where failure may damage farm buildings or agricultural land but such damage would be more or less confined to the dam owner's property. No loss of human life would be expected.

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* Tennessee Department of Conservation, Division of Water Resources, Rules and Regulations Applied to the Safe Dams Act of 1973. Chapter 0400-4-1.

DEFINITION OF CONDITION CLASSIFICATION

"Unsafe - Emergency" - A dam in a state of imminent failure. State and local authorities and downstream residents should be advised immediately, reservoir drained, or combination of the above (e.g., advanced piping, major slope instability, recent sudden collapse of a portion of the foundation, imminent overtopping, etc.).

"Unsafe - Nonemergency" - A dam with obviously serious deficiencies which clearly could develop, or are developing, into failure modes but do not yet pose the threat of imminent failure. State and local authorities should be advised promptly and remedial work should begin as soon as practical. Someone should be assigned to periodically check on the dam's condition until remedial work is begun. Drawing down the reservoir should be considered, e.g., flowing seepage from embankment which could lead to piping, evidence of solution channels or cavitation in the foundation, seriously inadequate spillway capacity as per ETL 1110-2-234, history of recurring slope instability, etc.).

"Significantly Deficient" - A dam with deficiencies which, if left unchecked, would likely become serious deficiencies and could ultimately result in failure. Advise State authorities and recommend remedial work be scheduled in time to prevent substantial further deterioration of the condition(s)--usually within six months to a year or sooner (e.g., heavy growth of sizeable trees on slopes, potentially serious erosion, spillway discharge channel too close to embankment, etc.).

"Deficient" - A dam with deficiencies which need attention but which would not likely effect the safety of the dam unless left unchecked for a long period of time. Advise State authorities and recommend remedial action at owner's convenience but before the problem can escalate into a significant deficiency (e.g., brush and/or few or very small trees on embankment, long term deterioration of masonry or metal outlet features, formation of deep ruts in embankment roadway, deterioration of riprap, etc.).

"Not Deficient" - Well constructed and maintained dam with no apparent deficiencies relative to its safety and structural integrity.

APPENDIX H

CORRESPONDENCE

ORNED-G

NON-FEDERAL DAM INSPECTION REVIEW BOARD
PO BOX 1070
NASHVILLE, TENNESSEE 37202

Commander, Nashville District
US Army Corps of Engineers
PO Box 1070
Nashville, TN 37202

1. The Interagency Review Board, appointed by the Commander on 19 June 1981, presents the following recommendations after meeting on 6 August 1981, to consider the Phase I investigation report on Cumberland Springs Dam performed by Winsett-Simmonds, Consterdine & Associates, Inc., under contract to the Tennessee Department of Conservation.

2. The condition classification should be changed from "significantly deficient" to "unsafe-nonemergency."

3. The Board is in agreement with other report conclusions and recommendations following minor revisions.

FRANK B. COUCH, JR.
Chief, Geotechnical Branch
Chairman

O'GENE W. BARKEMEYER
State Conservation Engineer
Soil Conservation Service

ROBERT A. HUNT
Director, Division of Water Resources
State of Tennessee

THOMAS N. PORTER
Hydraulics Engineer
Alternate, Hydrology and Hydraulics Branch

EDWARD B. BOYD
Hydrologic Technician
Alternate, US Geological Survey

L. E. LOCKETT
Structural Engineer
Alternate, Design Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 1070
NASHVILLE, TENNESSEE 37202

IN REPLY REFER TO
ORNED-G

12 AUG 1981

Honorable Lamar Alexander
Governor of Tennessee
Nashville, TN 37219

Dear Governor Alexander:

Please be informed of the results of an inspection, under authority of Public Law 92-367, conducted on Cumberland Springs Dam in Moore County, Tennessee. An inspection team, composed of personnel from Winsett-Simmonds, Consterdine and Associates, Inc., and a member of your Division of Water Resources, observed conditions which indicate a high potential for failure of the concrete dam due to seriously inadequate spillway capacity.

Cumberland Springs Dam is classified as a high hazard potential, small size dam and, as such, must be able to regulate at least a one-half probable maximum flood (1/2 PMF) to conform to inspection program guidelines. An analysis of the hydrology associated with the dam reveals the dam would be substantially overtopped by both a one-half and a full probable maximum flood.

In view of the serious spillway inadequacy, this dam is considered unsafe. While I do not view this as an emergency at this time, I recommend you initiate prompt action by the State to cause the owner to correct the spillway deficiency to minimize the risk to the residences located below the dam.

A report of the technical investigation will be furnished your office upon completion.

Sincerely,

LEE W. TUCKER
Colonel, Corps of Engineers
Commander

CF:
Mr. Robert A. Hunt, Director
Division of Water Resources
4721 Trousdale Drive
Nashville, TN 37220

DATE
ILME