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NATIONAL DAM SAFETY PROGRAM. DR. HENSON LAKE DAM (MO 31570), MI--ETC(U)
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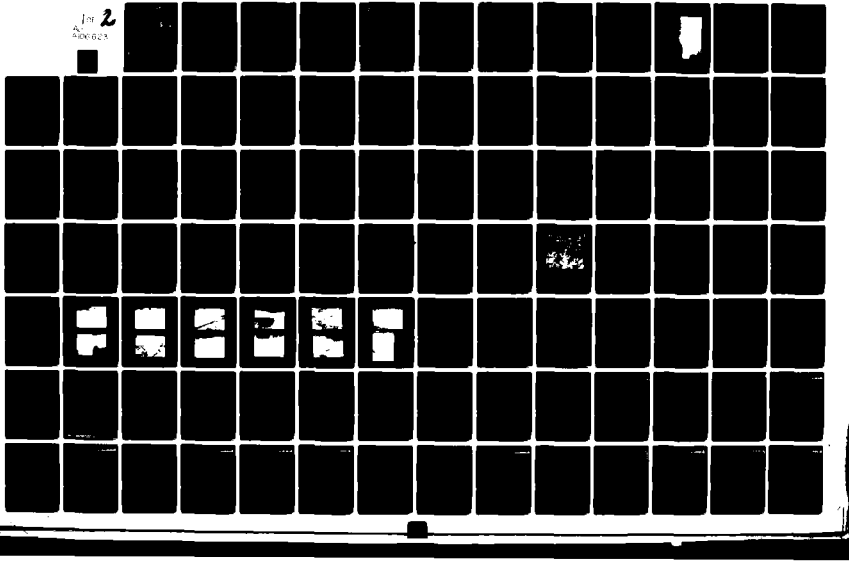

LEVEL II

1

MISSOURI · KANSAS CITY RIVER BASIN

DR. HENSON LAKE DAM
GASCONADE COUNTY, MISSOURI
MO. 31570

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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

St. Louis District

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

FOR: STATE OF MISSOURI

SEPTEMBER, 1980

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

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National Dam Safety Program
Dr. Henson Lake Dam (MO 31570)
Gasconade County, Missouri

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

cont'd on Pg. 1

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☆ U.S. G.P.O. 1980-665-141/1299

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

REPLY TO ATTENTION OF

SUBJECT: Dr. Hensen Lake Dam (Mo. 31570) Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Dr. Hensen Lake Dam (Mo. 31570).

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

SUBMITTED BY: _____ _____
Chief, Engineering Division Date

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

DR. HENSON LAKE DAM
GASCONADE COUNTY, MISSOURI

MISSOURI INVENTORY NO. 31570

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY
CONSOER, TOWNSEND AND ASSOCIATES, LTD.
ST. LOUIS, MISSOURI
AND
PRC ENGINEERING CONSULTANTS, INC.
ENGLEWOOD, COLORADO
A JOINT VENTURE

UNDER DIRECTION OF
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
FOR
GOVERNOR OF MISSOURI

SEPTEMBER 1980

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Dr. Henson Lake Dam, Missouri Inv. No. 31570
State Located: Missouri
County Located: Gasconade
Stream: An unnamed tributary of Frene Creek
Date of Inspection: April 23, 1980

Assessment of General Condition

Dr. Henson Lake Dam was inspected by the engineering firms of Consoer, Townsend and Associates, Ltd. and PRC Engineering Consultants, Inc. (A Joint Venture) of St. Louis, Missouri according to the U. S. Army Corps of Engineers "Engineer Regulation No. 1110-2-106" and additional guidelines furnished by the St. Louis District of the Corps of Engineers. Based upon the criteria in the guidelines, the dam is in the high hazard potential classification, which means that urban development with more than a small number of habitable structures could be effected in the event of failure of the dam. Within the estimated damage zone of one mile downstream of the dam are three dwellings, a state highway (Hwy. 100), a park and a campground which may be subjected to flooding, with possible damage and/or destruction, and possible loss of life. Dr. Henson Lake Dam is in the small size classification since it is less than 40 feet and more than 25 feet high.

The dam appears to be in poor condition. Our inspection and evaluation indicates that the spillway of Dr. Henson Lake Dam does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. Dr. Henson Lake Dam being a small size dam with a high hazard potential is required by the guidelines to pass from one-half of the Probable Maximum Flood to the Probable Maximum Flood without overtopping. Considering the number of inhabited dwellings located downstream of the dam, the PMF is considered the appropriate spillway design flood for Dr. Henson Lake Dam. It was determined that the reservoir/spillway system can accommodate approximately 50 percent of the Probable Maximum Flood without overtopping the dam. Our evaluation also indicates that the reservoir/spillway system can accommodate the one-percent chance flood (100-year flood) without overtopping the dam.

The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region.

Other deficiencies noted by the inspection team were the erosion on the upstream slope due to wave action and on the downstream slope due to surface erosion, a scarp on the upstream slope, possible seepage downstream of the toe of the dam, trees on the downstream and upstream slopes, obstructions in the spillway channel, some unprotected areas on the side slopes of the spillway channel, burrowing animals activities in the embankment, a need for periodic inspection by a qualified engineer and a lack of maintenance schedule. The lack of seepage and stability analyses on record is also a deficiency that should be corrected.

It is recommended that the owner take action to correct or control the deficiencies described above.

Walter G. Shifrin, P.E.

Overview of Dr. Henson Lake Dam

NATIONAL DAM SAFETY PROGRAM

DR. HENSON LAKE DAM, I.D. No. 31570

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DR. HENSON LAKE DAM, Missouri Inv. No. 31570

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

The Dam Inspection Act, Public Law 92-367 of August, 1972, authorizes the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspections. Inspection for Dr. Henson Lake Dam was carried out under Contract DACW 43-80-C-0094 between the Department of the Army, St. Louis District, Corps of Engineers, and the engineering firms of Consoer, Townsend & Associates, Ltd., and PRC Engineering Consultants, Inc. (A Joint Venture), of St. Louis, Missouri.

b. Purpose of Inspection

The visual inspection of Dr. Henson Lake Dam was made on April 23, 1980. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures.

c. Scope of Report

This report summarizes available pertinent data relating to the project, presents a summary of visual observations made during the field inspection, presents an assessment of hydrologic and hydraulic conditions at the site, presents an assessment of the structural adequacy of the various project features and assesses the general condition of the dam with respect to safety.

Subsurface investigations, laboratory testing and detailed analyses were not within the scope of this study. No warranty as to the absolute safety of the project features is implied by the conclusions presented in this report.

It should be noted that in this report reference to left or right abutments is viewed as looking downstream. Where left abutment or left side of the dam is used in this report, this also refers to the north abutment or side, and right to the south abutment or side.

d. Evaluation Criteria

The inspection and evaluation of the dam is performed in accordance with the U.S. Army Corps of Engineers "Engineer Regulation No. 1110-2-106" and additional guidelines furnished by the St. Louis District office of the Corps of Engineers for Phase 1 Dam Inspection.

1.2 Description of the Project

a. Description of Dam and Appurtenances

The following description is based upon observations and measurements made during the visual inspection. No design or as-built drawings were available for the dam or appurtenant structures.

The dam is an earthfill structure between earth abutments. The main portion of the dam has a crest width of 9 feet and crest length of 300 feet which runs between the spillway and the left abutment. At the left abutment, the crest extends for approximately another 100 feet. This section is approximately perpendicular to the main section in the direction of the reservoir. The main section has a slight curvature in the alignment, convex towards the downstream. The crest elevation is at approximately 575 feet above mean sea level (MSL). The upstream slope was measured to be 1 vertical to 1 horizontal (1V to 1H) from the crest to the water surface. The downstream slope was measured to be 1V to 1H. The maximum height of the embankment was measured to be 29 feet. The right half of the embankment was only 15-foot high. This portion of the embankment appeared to be placed upon a natural shelf of the right abutment. No riprap protection was provided on the upstream slope.

Dr. Henson Lake Dam has only one spillway and the spillway is located just to the right of the right abutment. It functions as an open channel conveying the flow past the toe of embankment to a vertical rock wall face, about 10 feet in height over which the flow spills to the downstream channel below. As the flow moves over the crest at the spillway inlet, it enters a trapezoidal channel having a 24 foot top

width and a 10 foot bottom width; the side slopes vary from 1V to 2.25H to 1V to 1.14H and the slope of the invert is about 1.79%. The channel is well defined and its centerline is almost perpendicular to the axis of the dam at its beginning and for the first 70 feet, after which the centerline is sharply curved to the left; it is immediately after this curve that the flow spills over the rock wall face. It is fairly evident that the spillway invert is close to bedrock.

There are no low-level drains or controlled outlet works provided for this dam.

b. Location

Dr. Henson Lake Dam had no name prior to the visual inspection and has now been named after its present owner. It is located in Gasconade County in the state of Missouri, across an unnamed tributary to Frene Creek whch is a tributary to the Missouri River. The damsite is slightly west of the community of Hermann on the banks of the Missouri River, and can be found on the 7.5 minute series of the Hermann, Missouri Quadrangle in Section 35, Range 5 West, Township 46 North.

c. Size Classification

According to the "Recommended Guidelines for Safety Inspection of Dams" by the U.S. Department of the Army, Office of the Chief Engineer, the dam is classified in the dam-size category as being "small" since its height is less than 40 feet and more than 25 feet. The dam falls below the "small" size classification by storage criteria, since its storage is less than 50 acre-feet. The overall size classification is

determined by the larger of the two sizes as determined by storage and the height of the dam. The overall size classification is accordingly "small".

d. Hazard Classification

The dam has been classified as having a "high" hazard potential in the National Inventory of Dams, on the basis that in the event of failure of the dam or its appurtenances, excessive damage could occur to downstream property, together with the possibility of the loss of life. Our findings concur with this classification. Within the estimated damage zone, extending one mile downstream of the dam, are three dwellings, a state highway, a park and a campground.

e. Ownership

Dr. Henson Lake Dam is owned privately by Dr. and Mrs. Robert Henson. The mailing address is Dr. and Mrs. Robert Henson, Route 1, Box 308, Hermann, Missouri, 65041.

f. Purpose of Dam

The purpose of the dam is to impound water for recreational use as a private lake.

g. Design and Construction History

According to the owner, Dr. Robert Henson, the dam was built in 1953 by Mr. Amel Ensing of Hermann, Missouri. The original owner of the dam and Mr. Ensing are deceased. It is very doubtful if there are any plans or specifications for the dam.

The northwest end of the lake was deepened about five years ago. The excavated material was used for the fill for a nursing home in Hermann, Missouri.

h. Normal Operational Procedures

The dam is used to impound water for recreational use. Normal procedure is to allow the lake level to remain as full as possible with the water level being controlled by rainfall, runoff, evaporation, and elevation of the spillway crest.

1.3 Pertinent Data

a. Drainage Area (square miles):	0.089
b. Discharge at Damsite	
Estimated experienced maximum flood (cfs):	20
Estimated ungated spillway capacity with reservoir at top of dam elevation (cfs):	446
c. Elevation (Feet above MSL)	
Top of dam (minimum):	575
Spillway crest:	570.6
Normal Pool:	570.6
Maximum Experienced Pool:	571.3
Observed Pool:	570.6
d. Reservoir	
Length of pool with water surface at top of dam elevation (feet):	700
e. Storage (Acre-Feet)	
Top of dam (minimum):	16
Spillway crest:	5
Normal Pool:	5
Maximum Experienced Pool:	6±
Observed Pool:	5
f. Reservoir Surfaces (Acres)	
Top of dam (minimum):	3.5
Spillway crest:	2
Normal Pool:	2
Maximum Experienced Pool:	2+
Observed Pool:	2

g. Dam

Type:	Earthfill
Length:	400 feet
Structural Height:	29 feet
Hydraulic Height:	29 feet
Top width:	9 feet
Side slopes:	
Downstream	1V to 1H (measured)
Upstream	1V to 1H (measured)
Zoning:	Unknown
Impervious core:	Unknown
Cutoff:	Unknown
Grout curtain:	Unknown

h. Diversion and Regulating Tunnel — None

i. Spillway

Type:	Trapezoidal open channel, uncontrolled
Length of crest:	10 feet
Crest Elevation (feet above MSL):	570.6

j. Regulating Outlets — None

SECTION 2: ENGINEERING DATA

2.1 Design

No design drawings or data are available for the dam.

2.2 Construction

The dam was built by Mr. Amel Ensing (deceased) of Hermann, Missouri in 1953. No construction records or data are available relative to the construction of the dam.

2.3 Operation

No operation records are available for the dam.

2.4 Evaluation

a. Availability

No design drawings, design computations, construction data, or operational data are available.

In addition, no pertinent data were available for review of hydrology, spillway capacity, flood routing through the reservoir, outlet capacity, slope stability, seepage analysis, or foundation conditions.

b. Adequacy

The lack of engineering data did not allow for a definitive review and evaluation. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing and evaluating design, operation and construction data, but is based primarily on visual inspection, past performance history, and sound engineering judgement.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity

No valid engineering data are available.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

A visual inspection of the Dr. Henson Lake Dam was made on April 23, 1980. The following persons were present during the inspection:

Name	Affiliation	Disciplines
Dr. M.A. Samad	PRC Engineering Consultants, Inc.	Project Engineer, Hydraulics and Hydrology
Mark R. Haynes	PRC Engineering Consultants, Inc.	Soils and Mechanical
Robert G. McLaughlin	PRC Engineering Consultants, Inc.	Civil
Razi Quraishi	PRC Engineering Consultants, Inc.	Geology
John Lauth	Consoer, Townsend & Assoc., Ltd.	Civil and Structural

Specific observations are discussed below.

b. Dam

The dam crest supports a good growth of vegetative cover which appears to provide adequate protection against surface erosion. A few small depressions were observed near the center of the dam which appeared to be due to vehicular traffic and were not attributed to instability of the embankment. Some small 2 to 3 inch deep holes were observed which appeared to be due to livestock activity on the crest. There was no evidence of significant settlement or cracking on the crest. No significant deviations in horizontal or vertical alignment were apparent. There was no evidence observed indicating that the dam has ever been overtopped.

The upstream slope has no riprap protection. Considerable erosion has occurred above the water surface due to wave action. Scarps up to 12 inches high were observed above the water surface in which the slope was near vertical. One 6-foot wide scarp extending from the water surface to the crest was observed near the center of the dam. The scarp appears to have stabilized and was due to a past instability. The slope appeared to be adequately protected from surface erosion by an unmaintained vegetative cover. Three large trees and some small saplings were growing on the slope. Evidence of burrowing animals were observed on the slope. A few burrows approximately 3 to 4 inches in diameter were observed. No depressions, bulges or cracks which would indicate an instability in the embankment were apparent on the slope.

The downstream slope has a heavy unmaintained vegetative cover which appears to provide adequate protection against surface erosion. Nevertheless, some erosion gullies were observed which were apparently due to past erosion. Some

trees were observed growing on the slope. One area of standing water was observed downstream of the toe of the dam. It was undetermined whether the standing water was due to seepage through the embankment or foundation or some other source. No measurable seepage was observed. Due to the heavy vegetative cover, a comprehensive inspection of the slope was hampered. No depressions or bulges which would indicate an instability of the slope were apparent.

Both abutments appeared to be stable. The left abutment supported a gravel access road which runs nearly perpendicular to the embankment. The right abutment supported the spillway. Rock outcrops were observed on the right abutment in the spillway channel. No erosion or instabilities which would affect the safety or stability of the dam were apparent on either of the abutments. No seepage was observed along either of the embankment/abutment contacts.

c. Project Geology and Soils

(1) Geology

The damsite is located on an unnamed tributary of the Frene Creek in the Salem Plateau section of the Ozark Plateaus Physiographic Province. Deep dissection of topography by major streams is one of the important characteristics of the Salem Plateau section. There is a wide distribution of dolomites and limestones in the Salem Plateau. Cuesta-form topography is exhibited in this plateau section consisting of two major escarpments, namely the Crystal Escarpment and Burlington Escarpment. Deep dissection in dolomites and limestones is a major factor in the development of many springs in this area. The topography at the damsite vicinity is hilly with U to V shaped valleys. Elevation ranges from

900 feet M.S.L. (nearly 3.5 miles south of the damsite) to 570 feet M.S.L. at the damsite. The reservoir slopes are generally 15° to 25° from horizontal. The reservoir appears to be water tight. Localized erosional gullies were observed near the northern rim of the reservoir. These localized erosional gullies are not detrimental to the stability of the reservoir banks. The area at the damsite is covered with slope wash deposits of glacial-fluvial origin and loess, consisting of reddish-brown, silty clay, with some fine sand. The inlet and outlet areas of the unnamed tributary of the Frene Creek contain Quaternary alluvium. Outcrops of Ordovician, moderately weathered, hard Dolomitic rocks, interbedded with moderately weathered, hard, sandstone and shales with a dip of 5° towards the west and a strike of N-S are exposed as the spillway cut and the downstream channel of the spillway. The areal bedrock geology beneath the slope wash deposits as shown on the Geologic map of Missouri (1979), Plate 3 consists of Pennsylvanian rocks undifferentiated, Ordovician St. Peters sandstone and Dolomitic rocks.

No faults have been identified in the vicinity of the damsite. The closest trace of a fault to the damsite is the Cuba Fault, nearly 25 miles south of the damsite. The Cuba Fault had its last movement in post-Pennsylvanian time. This fault appears to have no effect on the damsite.

Dr. Henson Lake Dam consists of an homogeneous earthfill embankment and a spillway located at the right end of the embankment. No boring logs or construction reports were available which would indicate foundation conditions encountered during construction. Based on the visual inspection, it is assumed the embankment probably rests on Brownish Gray Calcareous Sandstone interbedded with Dolomite. The spillway is cut into hard sandstone interbedded with Dolomite.

The spillway rock cut slopes are stable; minor localized rock debris were observed at the foot of the slope at the downstream channel walls of the spillway.

(2) Project Soils

According to the "Missouri General Soil Map and Soil Association Descriptions" published by the Soil Conservation Service, the materials in the general area of the dam belong to the soil series of Menfro-Winfield in the Central Mississippi Valley Wooded Slopes family. The soils were basically formed from loess. The permeability of these soils is considered to be moderate.

Materials removed from the embankment on the crest and downstream slope approximately one foot below the vegetative cover appeared to be a light brown sandy silt. Based upon the Unified Soil Classification System, the soil would probably be classified as a ML. This soil type generally has the following characteristics: impervious with a coefficient of permeability less than 50 feet per year; medium to low shear strength; and intermediate to low resistance to piping.

d. Appurtenant Structures

The spillway approach slope up to the crest is about 6% and is clear of brush and debris. Downstream of the crest the spillway channel invert slope is about 1.79% and soon becomes somewhat clogged with overgrown grass, cattails, small trees, and miscellaneous debris. Some portions of the channel are not clogged, but grass is growing on the invert, which appears to lie directly over bedrock. One section of channel side slope is bare, possibly due to high velocity flow as it rounds the covered alignment and spills over the drop.

Basically the spillway appears stable and is adequately protected from surface erosion by grass that is for the most part too tall.

There were no low level drains or mechanically controlled outlet works provided for the dam.

e. Reservoir Area

The water surface elevation was 570.6 feet above M.S.L. on the day of the inspection.

The reservoir rim has mild slopes which appear to be of an easily erodible soil as there are quite a few wide erosion gullies along the left side of the reservoir. The land above the rim slopes up to a road on the left side of the reservoir and to a forest along the remainder of the reservoir. The mild slopes above the reservoir rim are grass covered until the trees. There are no houses built in the vicinity of the reservoir.

f. Downstream Channel

The downstream channel is well defined. The channel flows pass through a culvert underneath a light duty road which is about 700 feet downstream of the dam. Upstream from the culvert the channel has a bottom width of about 25 feet and a side flope of 1V to 1H on the right and 1V to 3H on the left side (looking downstream). Downstream from the culvert the channel is approximately 20 feet wide and has the same side slopes. The channel is obstructed by trees which could affect the hydraulic efficiency of the channel.

3.2 Evaluation

The visual inspection did not reveal any items which are sufficiently significant to indicate a need for immediate remedial action. The following conditions were observed which could affect the safety of the facility and will require maintenance within a reasonable period of time.

1. The trees observed on the downstream and upstream slopes pose a potential danger to the safety of the dam depending upon the extent of the root system. The roots present possible paths for piping through the embankment. The root systems can also do damage to the embankment from being uprooted by a storm.

2. The possible seepage indicated by the standing water downstream of the toe of the dam could affect the structural stability of the dam. If the rate of seepage were to increase, it is possible that the seepage could transport soil particles which could cause piping of embankment material which in turn could lead to an eventual failure of the embankment.

3. The erosion on the upstream slope due to wave action and on the downstream slope due to surface runoff could affect the safety of the dam if allowed to continue and should be properly repaired. Continual erosion will steepen the slopes which could lead to an eventual failure of the embankment.

4. Rodent activities on the upstream slope could jeopardize the safety of the dam. The holes created by the animals make avenues for possible piping.

5. The obstructed section of the spillway channel causes the water level of a high flow to rise thus causing higher backwater effects. Also, the tall grasses growing within the channel area cause the channel to operate at a higher friction factor.

6. The unprotected area of the spillway channel side slope at the downstream end will become further eroded with each additional high velocity flow.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

There are no specific procedures which are followed for the operation of this dam. The water level below the spillway crest is allowed to remain as high as possible.

4.2 Maintenance of Dam

The dam is maintained by the owner, Dr. Robert Henson. The maintenance of the dam appears to be inadequate. The downstream slope is covered with bushes, saplings and a few large trees. Several saplings and small trees are also growing on the upstream slope of the dam.

There have not been any major repairs done to the dam itself since its original construction.

4.3 Maintenance of Operating Facilities

There are no operating facilities associated with this dam.

4.4 Description of Any Warning System in Effect

The inspection team is not aware of any warning system in use at the dam site.

4.5 Evaluation

The maintenance at the dam appears to be inadequate at this time. The corrective measures listed in Section 7 should be undertaken within a reasonable period of time to improve the condition of the dam.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design

The watershed area of the Dr. Henson Lake Dam upstream from the dam axis consists of approximately 57 acres. The watershed area is mostly pasture and range land with some wooded areas. Land gradients in the watershed average roughly 13 percent. The Dr. Henson Lake Dam Reservoir is located on an unnamed tributary of Frene Creek. The reservoir is about 2400 feet upstream from the confluence of the unnamed tributary and Frene Creek. At its longest arm the watershed is approximately 1/2 mile long. A drainage map showing the watershed and the downstream hazard zone is presented as Plate 1 in Appendix B.

Evaluation of the hydraulic and hydrologic features of Dr. Henson Lake Dam was based upon criteria set forth in the Corps of Engineers' "Engineer Regulation No. 1110-2-106" and additional guidance provided by the St. Louis District of the Corps of Engineers. The Probable Maximum Flood (PMF) was calculated from the Probable Maximum Precipitation (PMP) using the methods outlined in the U.S. Weather Bureau Publication, Hydrometerological Report No. 33. The probable maximum storm duration was set at 24 hours, and storm rainfall distribution was based upon criteria given in the Corps of Engineers' EM 1110-2-1411 (Standard Project Storm). The Soil Conservation Service (SCS) method was used for deriving the unit hydrograph, utilizing the Corps of Engineers'computer program HEC-1

(Dam Safety Version). The unit hydrograph parameters are presented in Appendix B. The SCS method also was used for determining the loss rate. The hydrologic soil group of the watershed was determined by use of published soil maps. The hydrologic soil group of the watershed and the SCS curve number are presented in Appendix B. The curve number, unit hydrograph parameters, the PMP index rainfall and the percentages for various durations were directly input to the HEC-1 (Dam Safety Version) computer program to obtain the PMF hydrograph. The computed peak inflow of the PMF and one-half of the PMF are 1,537 cfs and 769 cfs, respectively.

Both the PMF and one-half of the PMF inflow hydrographs were routed through the reservoir by the Modified Puls Method also utilizing the HEC-1 (Dam Safety Version) computer program. A storm of 50 percent and 25 percent PMF, respectively, preceded the PMF and 50 percent PMF by four days. The reservoir was assumed at the mean annual high water level at the beginning of the antecedent storm. The mean annual high water level for Dr. Henson Lake was estimated to be at the crest of the spillway. The antecedent 50 percent PMF storm, when routed through the reservoir, leaves the reservoir at approximately the same elevation as the crest of the spillway at the end of the the four day period. Thus the reservoir was assumed at the spillway crest at the start of the routing computation for PMF, one-half of the PMF and other PMF ratio floods. The peak outflow discharges for the PMF and one-half of the PMF are 1,302 and 404 cfs, respectively. Only the PMF when routed through the reservoir resulted in overtopping of the dam.

The sizes of physical features utilized to develop the stage-outflow relation for the spillway and overtopping of the dam were prepared from field notes and sketches prepared during the field inspection. The reservoir elevation-area data were obtained from the U.S.G.S. Hermann, Missouri Quadrangle topographic map (7.5 minute series). The spillway and dam overtop-rating curve and the reservoir-elevation-area curve are presented as Plates 2 & 3, respectively, in Appendix B.

From the standpoint of dam safety, the hydrologic design of a dam must aim at avoiding overtopping. Overtopping is especially dangerous for an earth dam because of its erodable characteristics. The safe hydrologic design of an embankment dam requires a spillway discharge capability combined with an embankment crest height that can handle a very large and exceedingly rare flood without overtopping.

The Corps of Engineers designs dams to safely pass the Probable Maximum Flood that could be generated from the dam's watershed. This is generally the standard for dam safety where overtopping would pose any threat to human life. Accordingly, the hydrologic requirement for safety for this dam is the capability to pass the Probable Maximum Flood without overtopping.

b. Experience Data

It is believed that records of reservoir stage or spillway discharge are not maintained for this site. However, according to the owner, the maximum reservoir level was about 6-inches above the crest of the spillway.

c. Visual Observations

Observations made of the spillway during the visual inspection are discussed in Section 3.1d and evaluated in Section 3.2.

d. Overtopping Potential

As indicated in Section 5.1.a, only the Probable Maximum Flood, when routed through the reservoir, resulted in overtopping of the dam. The peak outflow discharges for the PMF and one-half of the PMF are 1,302 and 404 cfs, respectively. The maximum capacity of the spillway just before overtopping the dam is 446 cfs. The PMF overtopped the dam by 0.71 feet. The total duration of flow over the top of dam was 20 minutes. The spillway/reservoir system of Dr. Henson Lake Dam is capable of accommodating a flood equal to approximately 50 percent of the PMF just before overtopping the dam. The reservoir/spillway system of Dr. Henson Lake Dam will accommodate the one percent chance flood without overtopping. The results of the flood routings are summarized in the following Table.

Table: Summary of Routings of Floods

Flood Routed	Max. Pool Elevation (M.S.L.)	Maximum Discharge (cfs)	Depth of Overtopping (feet)	Duration of Overtopping (hrs)
100-yr	573.14	164	0	0
45% PMF	574.56	359	0	0
50% PMF	574.83	404	0	0
55% PMF	575.05	482	0.05	0.17
60% PMF	575.22	608	0.22	0.17
100% PMF	575.71	1302	0.71	0.33

The surface soils in the embankment appears to be sandy silt. The spillway, being a rock cut channel should be able to withstand high velocity flow during the PMF without being subject to excessive erosion; however, the downstream slope of the dam might be eroded and thus endanger the safety of the dam due to overtopping during the occurrence of the PMF.

The failure of the dam could cause extensive damage to the property downstream of the dam and possible loss of life. The estimated damage zone extends approximately one mile downstream of the dam. Within the damage zone are three dwellings, a state highway (Hwy. 100), a park and a campground.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

There were no major signs of settlement or distress observed on the embankment during the visual inspection. The wave erosion on the upstream slope and the surface runoff erosion on the downstream slope do not appear to affect the structural stability of the dam in their present condition. Also the possible seepage observed downstream of the toe does not appear to affect the stability of the dam in its present condition. There were no indications of past or present slope instability except for the 6-foot wide scarp observed near the center of the embankment which appears to be stable. In the absence of seepage and stability analyses, no quantative evaluation of this structure can be made.

Overall, the spillway crest and the channel appear to be in stable shape. However, some area of the channel side slope at the downstream end just before the drop is not protected against erosion.

b. Design and Construction Data

No design computations were uncovered during the report preparation phase. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available. No embankment or foundation soil parameters are availble for carrying

out a conventional stability analysis on the embankment. No construction data or specifications relating to the degree of embankment compaction are available for use in a stability analysis.

c. Operating Records

No operating records are available relating to the stability of the dam or appurtenant structures. The water level on the day of inspection was near the crest of the spillway, and it is assumed that the reservoir remains close to full at all times. No regulated outlet works or low level drain was provided for this dam.

d. Post Construction Changes

No post construction changes exist which will affect the structural stability of the dm.

e. Seismic Stability

The dam is located in Seismic Zone 1, as defined in "Recommended Guidelines for Safety Inspection of Dams" as prepared by the Corps of Engineers, and does not require a seismic stability analysis. An earthquake of the magnitude which would be expected in a Seismic Zone 1 should not cause distress to a well designed and constructed earth dam.

SECTION 7: ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

The assessment of the general condition of the dam is based upon available data and visual inspection. Detailed investigations, 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.

It should be realized that the reported condition of the dam is based upon observations of field conditions at the time of inspection along with data available to the inspection team.

It is also important to note that the condition of a dam depends upon 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 assurance that an unsafe condition could be detected.

a. Safety

The spillway capacity of Dr. Henson Lake Dam is found to be "Inadequate". The spillway/reservoir system will accommodate about 50 percent of the PMF without overtopping. The surface soils in the embankment appears to be sandy silt. The dam is overtopped by about a foot during the occurrence of the PMF. The spillway, being a rock cut channel, should be

able to withstand high velocity flow during the PMF without being subject to excessive erosion; however, the downstream slope of the dam might be eroded and thus endanger the safety of the dam due to overtopping during the occurrence of the PMF.

No quantitative evaluation of the safety of the embankment can be made in view of the absence of seepage and stability analyses. The present embankment, however, appears to have performed satisfactorily since its construction without failure or evidence of instability. There was no evidence indicating the dam has ever been overtopped.

The safety of the dam can be improved if the deficiencies described in Section 6.1a and below are corrected as described in Section 7.2b. The trees observed on the downstream and upstream slopes pose a potential danger to the safety of the dam depending upon the extent of the root system. The roots of trees present possible paths for piping through the embankment. The root systems can also do damage to the embankment from being uprooted by a storm. Therefore, the trees should be removed from the embankment under the guidance of an engineer experienced in the design and construction of earthen dams.

The existence of burrowing animals on the embankment could jeopardize the safety of the dam. The holes created by the animals make avenues for possible piping. The extent of damage to the embankment done by the burrowing animals should be determined and corrective measures undertaken as required.

A clean, well-trimmed spillway channel contributes to the overall efficiency and the safety of the dam.

b. Adequacy of Information

Information relating to the design and construction of the dam is lacking. The conclusions presented in this report are based on field measurement, past performance and present condition of the dam. Information on the design hydrology, hydraulic design, and the operation and maintenance of the dam were not available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available which is considered a deficiency.

c. Urgency

The remedial measures recommended in Paragraph 7.2 should be accomplished within a reasonable period of time, and the item recommended in paragraph 7.2a should be pursued on a high priority basis.

d. Necessity for Phase II Inspection

Based upon results of the Phase I inspection, and if the remedial measures recommended in Paragraph 7.2 are undertaken, a Phase II inspection is not felt to be necessary.

7.2 Remedial Measures

a. Alternatives

There are several general options which may be considered to reduce the possibility of dam failure or to diminish the harmful consequences of such a failure. Some of these options are:

1. Increase the spillway capacity to pass the Probable Maximum Flood without overtopping the dam.

2. Increase the height of the dam enough to pass the PMF without overtopping the dam; an investigation should also be done that includes studying the effects on the structural stability of the existing embankment. The overtopping depth during the occurrence of the PMF, stated in Section 5.1d, is not the required or recommended increase in the height of the dam.

3. A combination of 1 and 2 above.

b. O & M Procedures

1. The erosion on the upstream slope due to wave action and on the downstream slope due to surface erosion and the 6-foot wide scarp on the upstream slope should be backfilled with a suitable material and properly compacted. The slopes should then be graded and properly protected from further damage due to erosion.

2. The possible seepage downstream of the toe of the embankment should be monitored to detect any changes in turbidity, location or quantity. Any changes should be reported and investigated further.

3. Remove the trees from the downstream and upstream slopes of the dam. Removal of large trees should be under the guidance of an engineer experienced in the design and construction of earthen dams.

4. Determine the extent of damage done to the embankment by burrowing animals and corrective repairs made as required. All burrowing animals should be eliminated from the embankment and their burrows properly backfilled and compacted.

5. The spillway channel bottom should be cleaned of all tall grass and cattail growth and miscellaneous debris (e.g. plastic bottles); other grassy areas of the channel bottom should be either cut very short or prevented from growing at all if on bedrock.

6. The unprotected areas of the spillway channel side slopes should be given protection against any erosion from high velocity flows.

7. Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of earth dams.

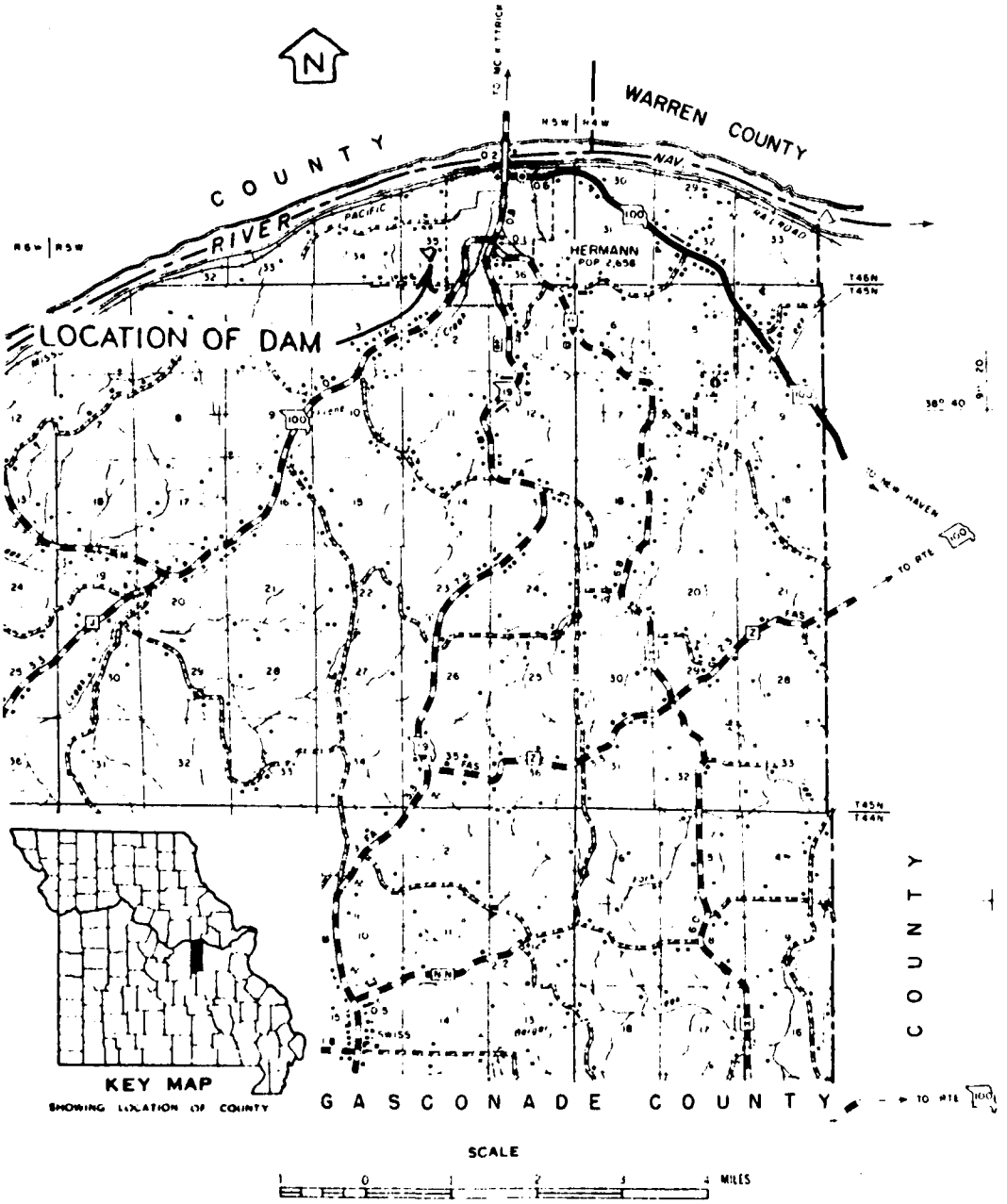
8. The owner should initiate the following programs:

   (a) Periodic inspection of the dam by a professional engineer experienced in the design and construction of earthen dams.

   (b) Set up a maintenance schedule and log all visits to the dam for operation, repairs and maintenance.

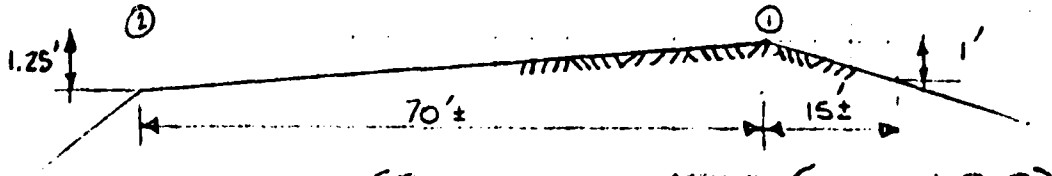
PLATES

PLATE 1

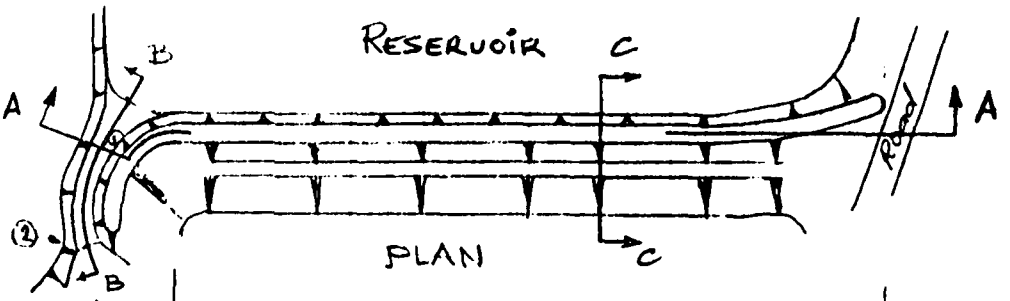


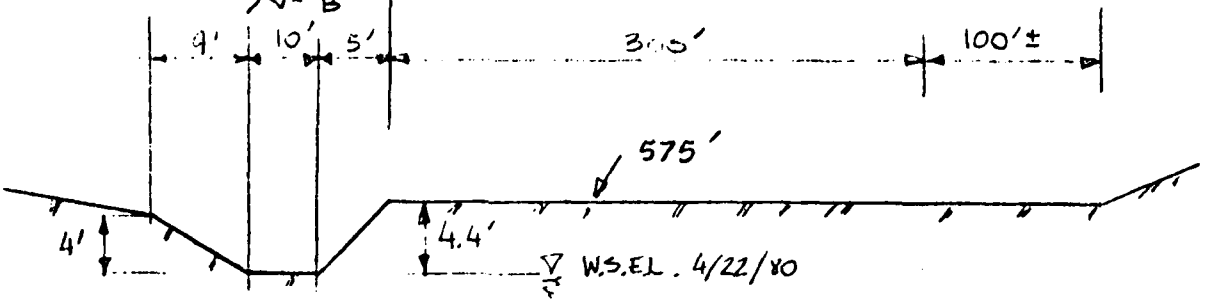
LOCATION MAP - DR. HENSON LAKE DAM

MO. 31570

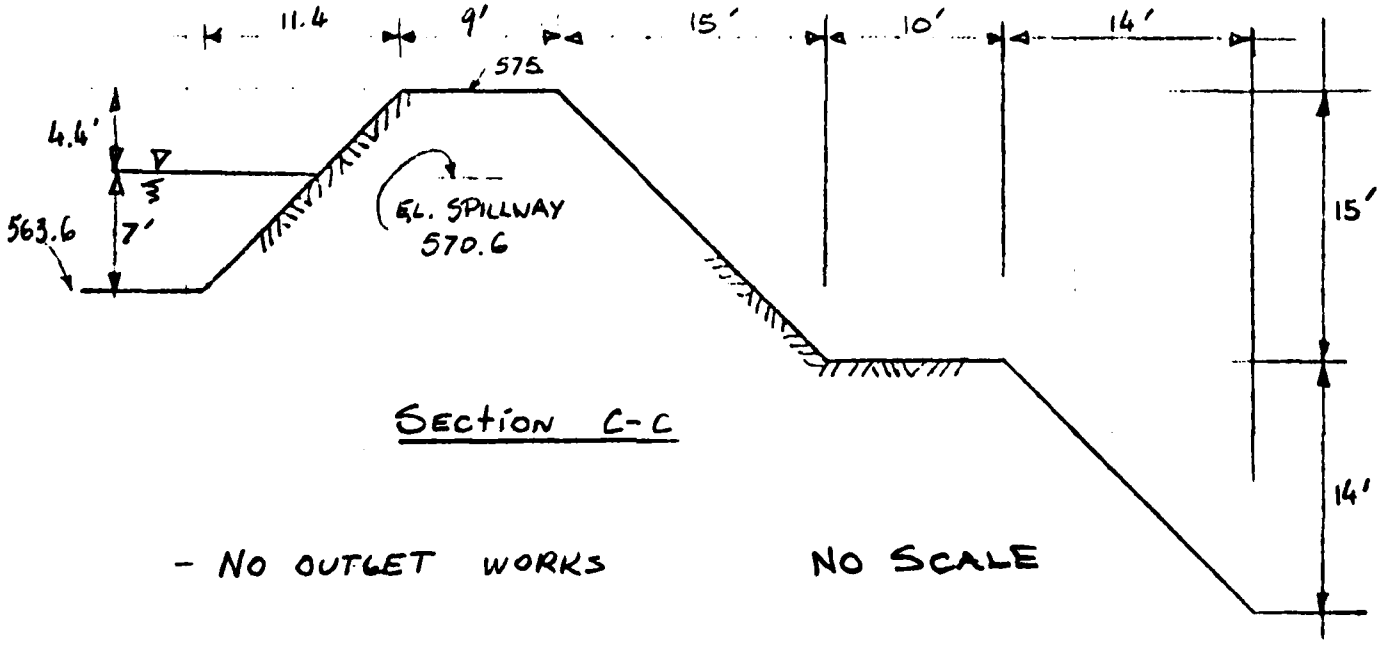


SPILLWAY PROFILE (SECTION B-B)





ELEVATION (SECTION A-A)

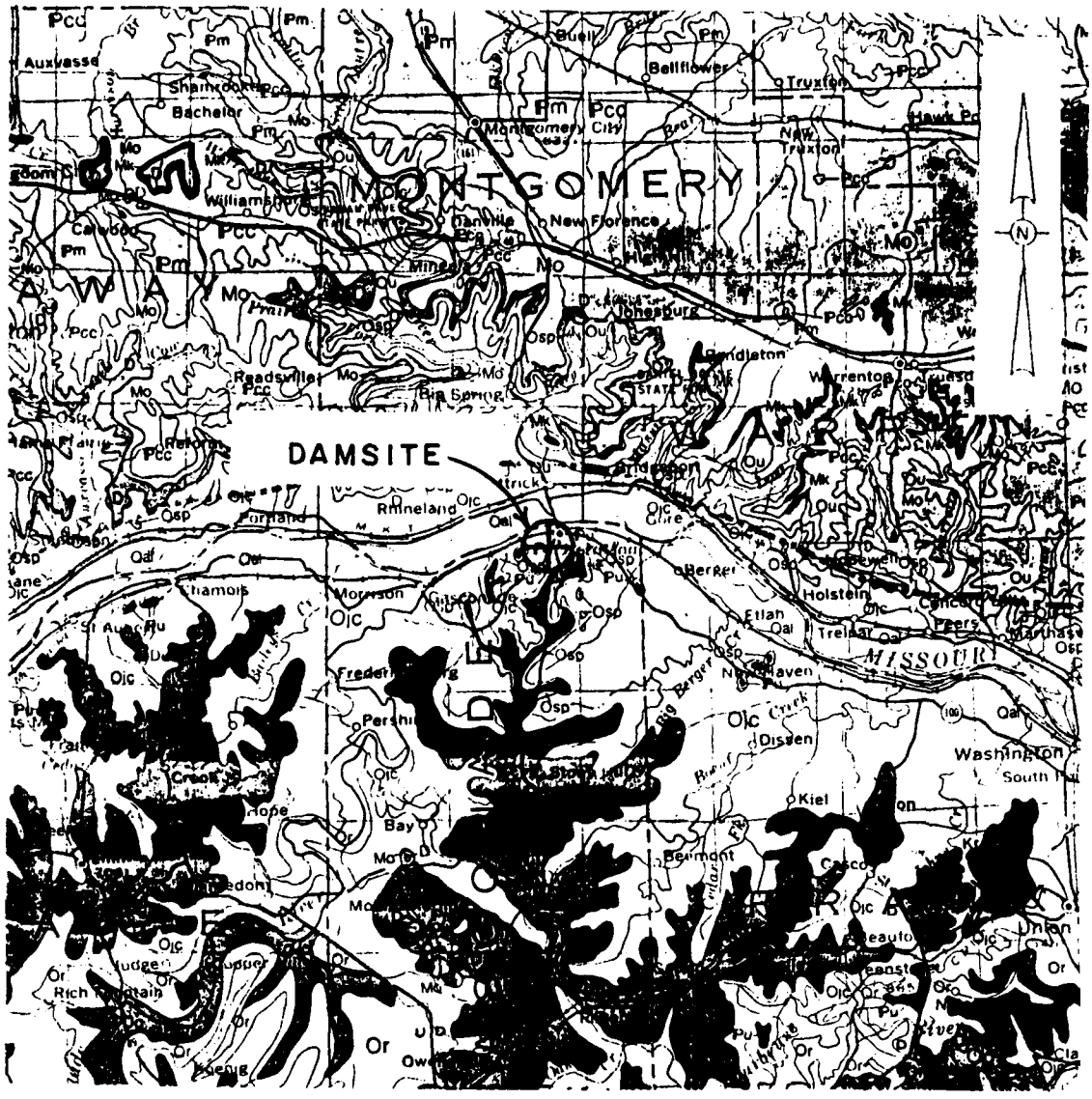


Section C-C

- NO OUTLET WORKS

NO SCALE

DR. HENSON LAKE DAM
PLAN, ELEVATION, SECTION
AND SPILLWAY PROFILE



SCALE

10 0 10 20 30 40 Miles

⊕ LOCATION OF DAM

NOTE: LEGEND OF THIS DAM IS ON PLATE

REFERENCE:

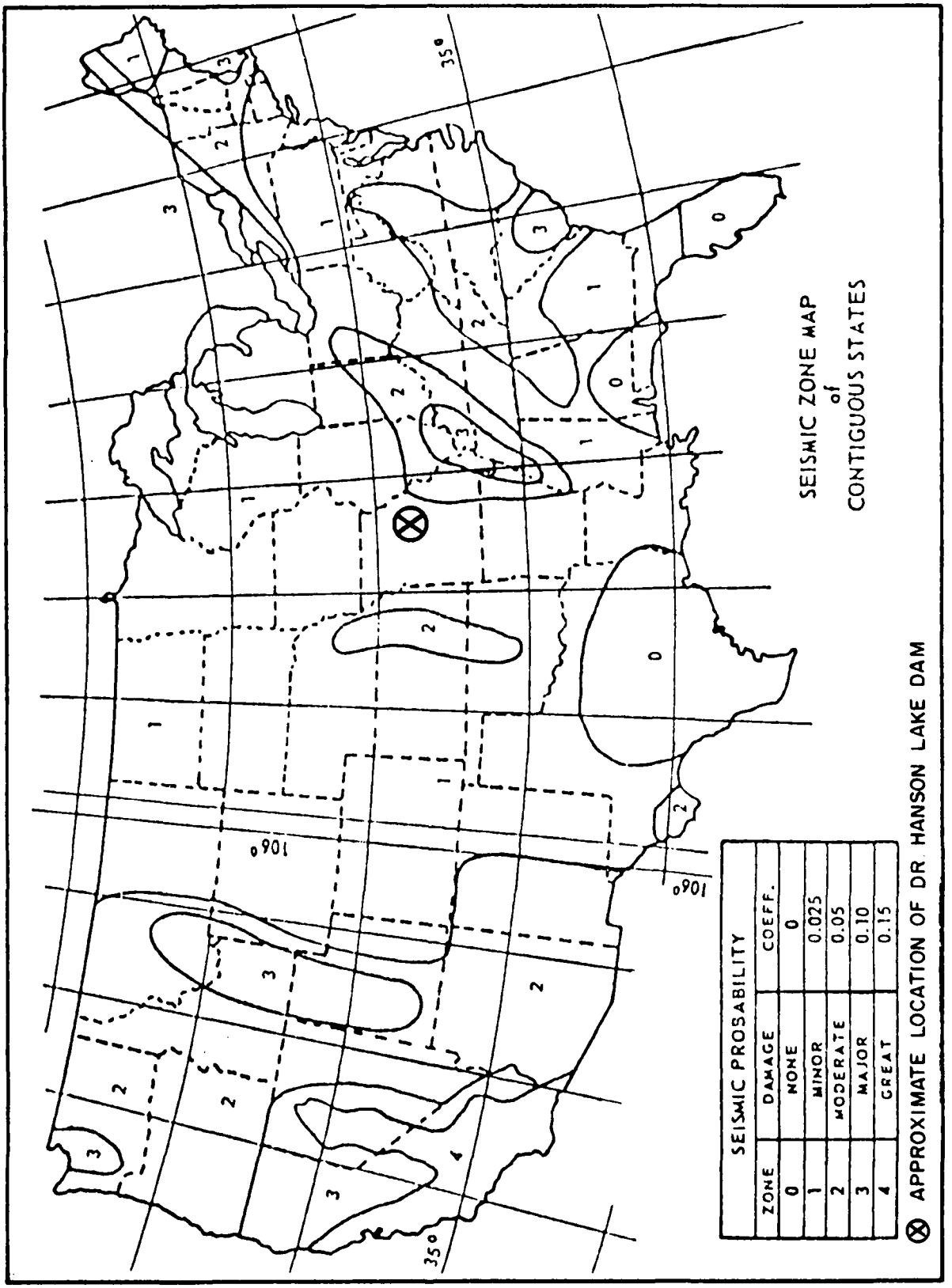
GEOLOGIC MAP OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES
MISSOURI GEOLOGICAL SURVEY
KENNETH H. ANDERSON, 1979

REGIONAL GEOLOGICAL MAP OF DR. HENSON LAKE DAM

LEGEND

PERIOD	SYMBOL	DESCRIPTION
QUATERNARY	Qal	ALLUVIUM: SAND, SILT, GRAVEL
PENNSYLVANIAN	Pu	PENNSYLVANIAN UNDIFFERENTIATED
	Pm	MARMATON GROUP: CYCLIC DEPOSITS OF SHALE, LIMESTONE AND SANDSTONE
	Pcc	CHEROKEE GROUP: CYCLIC DEPOSITS OF SHALE, LIMESTONE AND SANDSTONE
MISSISSIPPIAN	Mm	ST. LOUIS FORMATION: LIMESTONE INTERBEDDED WITH SHALE.
	Mm	SALEM FORMATION: LIMESTONE INTERBEDDED WITH SHALE AND SILTSTONE
	Mm	WARSAW FORMATION: ARGILLACEOUS LIMESTONE AND CALCAREOUS SHALE
	Mo	KEOKUK- BURLINGTON FORMATION: CHERTY GRAYISH BROWN SANDY LIMESTONE
	Mk	NORTHVIEW- COMPTON AND BACHELOR FORMATION
DEVONIAN	D	CHATTANOOGA SHALE, SYLAMORE SANDSTONE
ORDOVICIAN	Omk	MAQUOKETA SHALE, KIMMSWICK LIMESTONE
	Odp	DECORAH FORMATION: GREEN TO GRAY CALCAREOUS SHALE WITH THIN FOSSILIFEROUS LIMESTONE
	Osp	ST PETER SANDSTONE
	Ojc	SMITHVILLE FORMATION POWELL DOLOMITE
	Or	ROUBIDOUX FORMATION

PLATE 5


SEISMIC ZONE MAP
of
CONTIGUOUS STATES
SEISMIC PROSABILITY
ZONE | DAMAGE | COEFF.
0 | NONE | 0
1 | MINOR | 0.025
2 | MODERATE | 0.05
3 | MAJOR | 0.10
4 | GREAT | 0.15
⊗ APPROXIMATE LOCATION OF DR HANSON LAKE DAM
35°
106°
090

APPENDIX A

PHOTOGRAPHS

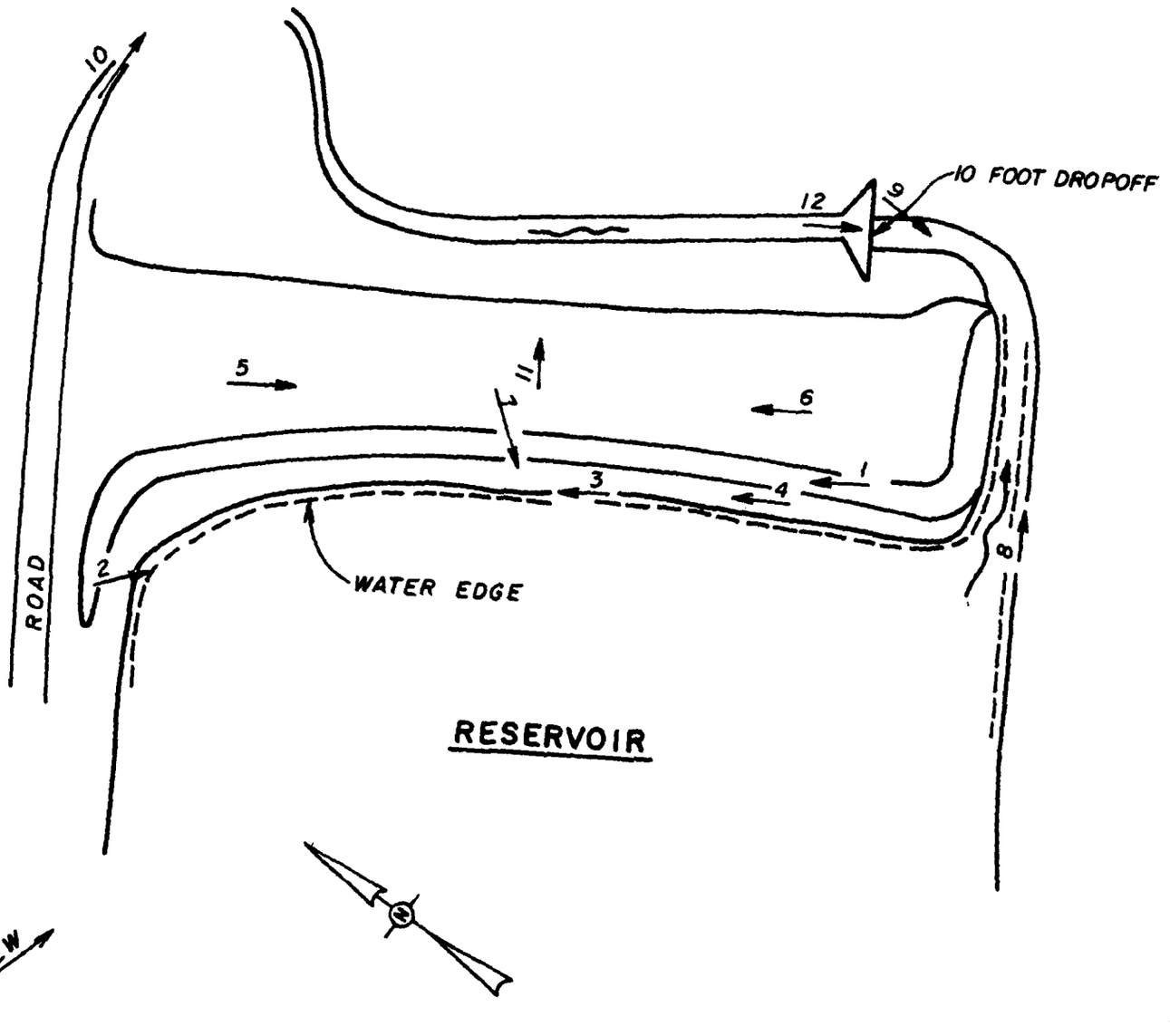


PHOTO INDEX FOR DR. HENSON LAKE DAM

Dr. Henson Lake Dam

Photographs

Photo 1 - Top of dam showing good grass cover.

Photo 2 - Upstream slope of dam showing trees growing on slope (looking right).

Photo 3 - Upstream slope of dam (looking left) showing brush and grass growth.

Photo 4 - View of hole in upstream slope of dam--indicates burrowing activity.

Photo 5 - Downstream slope of dam showing dense grass growth and trees growing on slope (looking right).

Photo 6 - Downstream slope of dam showing dense grass and trees (looking left).

Photo 7 - Reservoir rim showing tree-lined mild slopes.

Photo 8 - Entrance to spillway showing thick grass and reeds within channel (look downstream).

Photo 9 - Spillway channel showing turn and point of 10-foot drop.

Photo 10 - View of downstream channel crossing under road.

Photo 11 - View of downstream channel showing trees lining channel and nearby structure.

Photo 12 - Outcrop-Ordovician, moderately weathered, grey Dolomite interbedded with sandstones and shale.

Photo 1

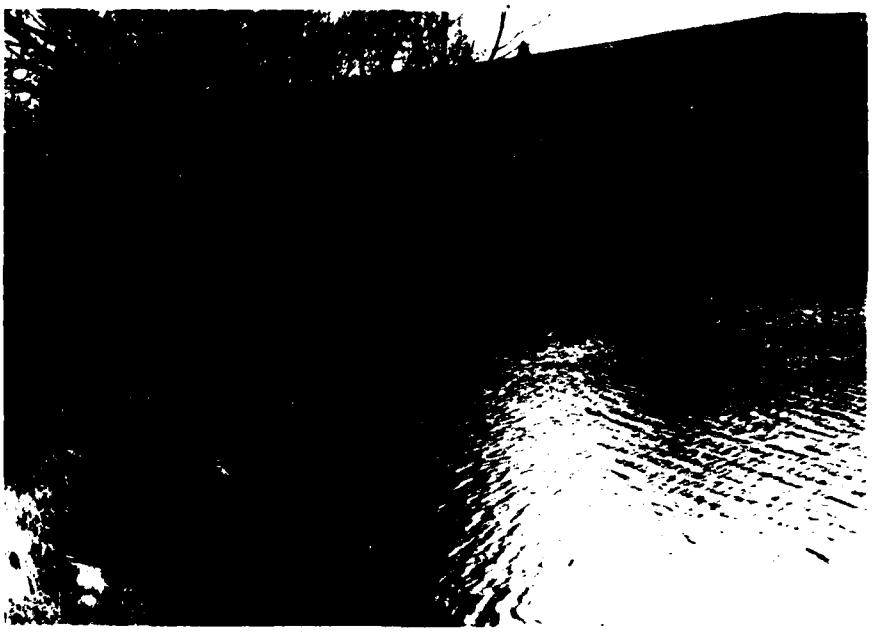


Photo 2

Photo 3

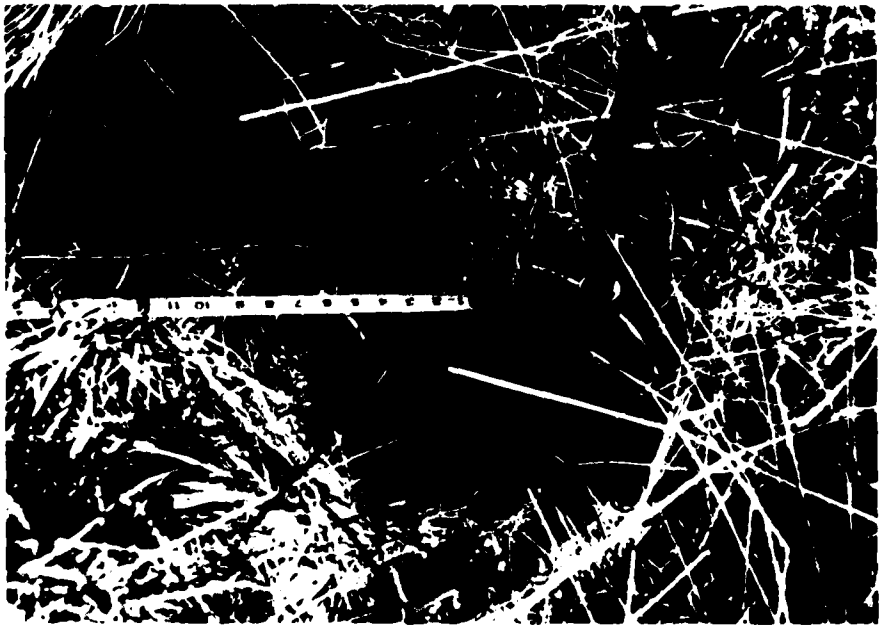


Photo 4

Photo 5

Photo 6

Photo 7

Photo 8

Photo 9

Photo 10

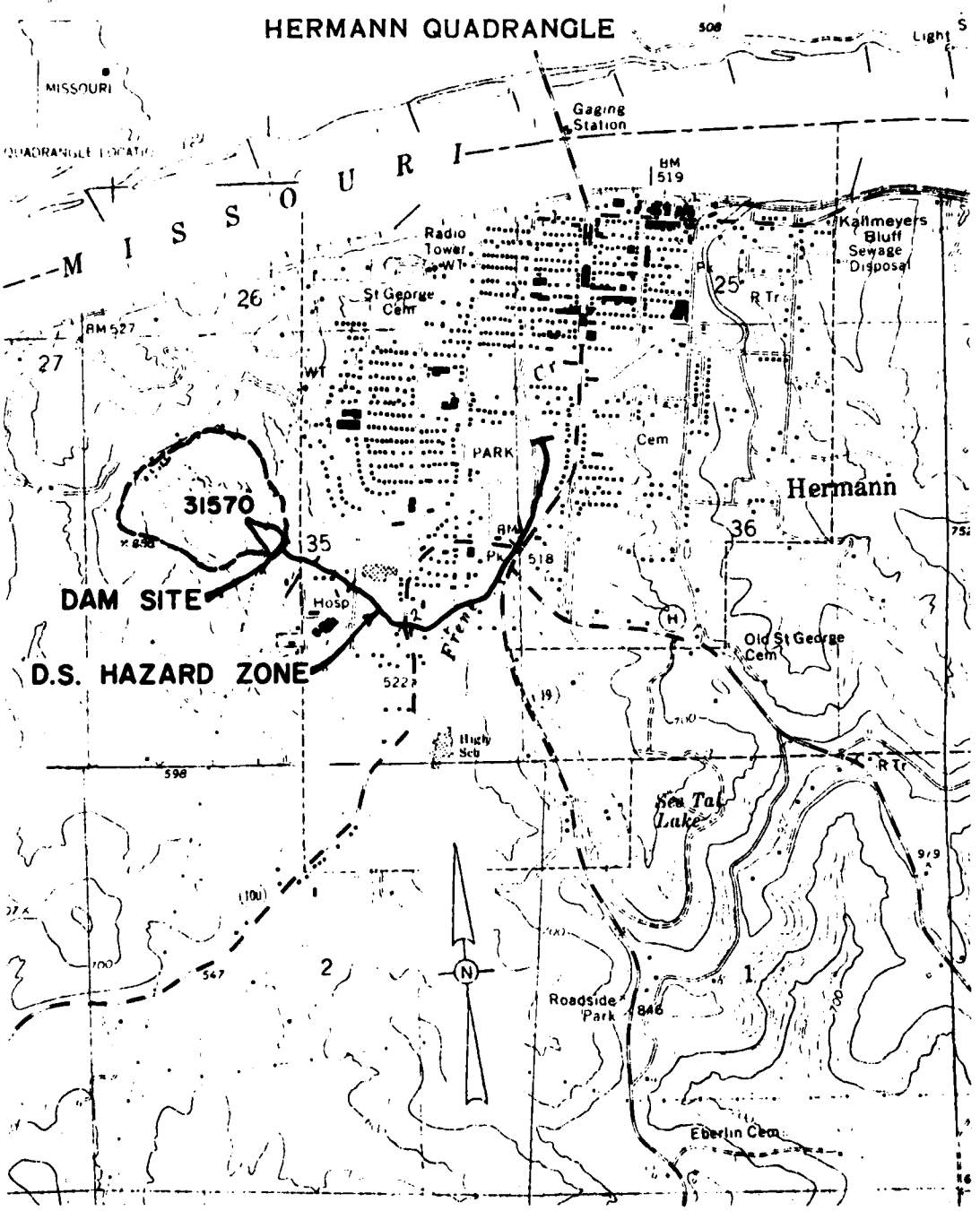
Photo 11

Photo 12

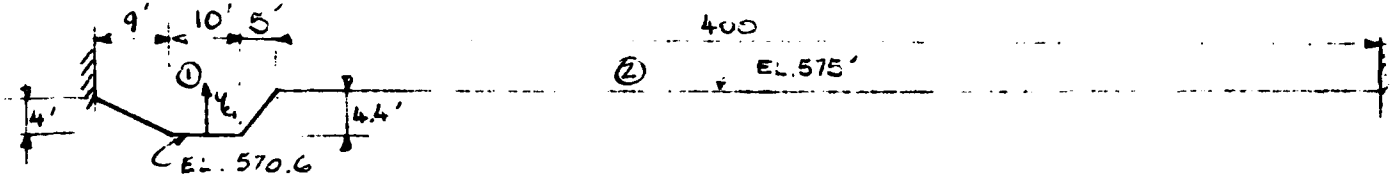
APPENDIX B

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

PLATE 1, APPENDIX B



DR. HENSON LAKE DAM MO 31570
DRAINAGE BASIN
B-2



y_{c_1}	A_{c_1}	T_{c_1}	$V_{c_1}=\sqrt{\frac{A_{c_1}g}{T_{c_1}}}$	$Q_0 = V_{c_1} A_{c_1}$	$V_{c_1}^2/2g$	H_1	H_2	C_2	Q_2	WSEL	Q_1+Q_2
0										570.60	0
0.5	5.4	11.1	3.9	21	0.23	0.73				571.33	21
1.0	11.7	13.4	5.3	62	0.44	1.44				572.04	62
1.5	18.8	15.1	6.3	119	0.62	2.12				572.72	119
2.0	26.8	16.8	7.2	192	0.80	2.80				573.40	192
2.5	35.6	18.5	7.9	280	0.96	3.46				574.06	280
3.0	45.2	20.2	8.5	385	1.12	4.12				574.72	385
3.2	49.3	20.8	8.7	431	1.18	4.38				574.98	431
3.4	53.6	21.5	8.9	480	1.25	4.65	0.25	2.98	149	575.25	629
3.6	57.9	22.2	9.2	531	1.31	4.91	0.51	3.02	440	575.51	971
3.8	62.5	22.9	9.4	586	1.37	5.17	0.77	3.03	819	575.77	1405
4.0	67.1	23.6	9.6	643	1.42	5.42	1.02	3.04	1251	576.02	1894
4.5	79.0	24.0	10.3	813	1.65	6.15	1.75	3.07	2841	576.75	3654

B-3

$WSEL = y_{c_1} + \frac{V_{c_1}^2}{2g} + 570.6$ $\quad H_1 = y_{c_1} + \frac{V_{c_1}^2}{2g}$ $\quad H_2 = H_1 - 4.4$

$Q_2 = 400\, C_2\, H_2^{3/2}$

$y_{c_1} \leq 4$ $\quad A_{c_1} = y_{c_1}(1.69\, y_{c_1} + 10)$
$T_{c_1} = 3.34\, y_{c_1} + 10$

$y_{c_1} \geq 4.4$ $\quad A_{c_1} = 24\,(y_{c_1} - 1)$
$T_{c_1} = 24$

ECI-4 **PRC ENGINEERING CONSULTANTS, INC.**

DAM SAFETY — SHEET NO. 2 OF 2

DR. JENSON LAKE DAM #31570 — JOB NO. 1263

BY PZ DATE Sept 80

VERIFICATION OF CRITICAL DEPTH ASSUMPTION

$\underline{y \leq 4} \Rightarrow A = y(1.69y + 1.0)$, $P = 3.98y + 10$

Assume $n = 0.03$, $S = 1.25/70$

$$Q = \frac{1.49}{0.03} \times \sqrt{\frac{1.25}{70}} \times \frac{A^{5/3}}{P^{2/3}} = 0.64 \frac{A^{5/3}}{P^{4/3}}$$

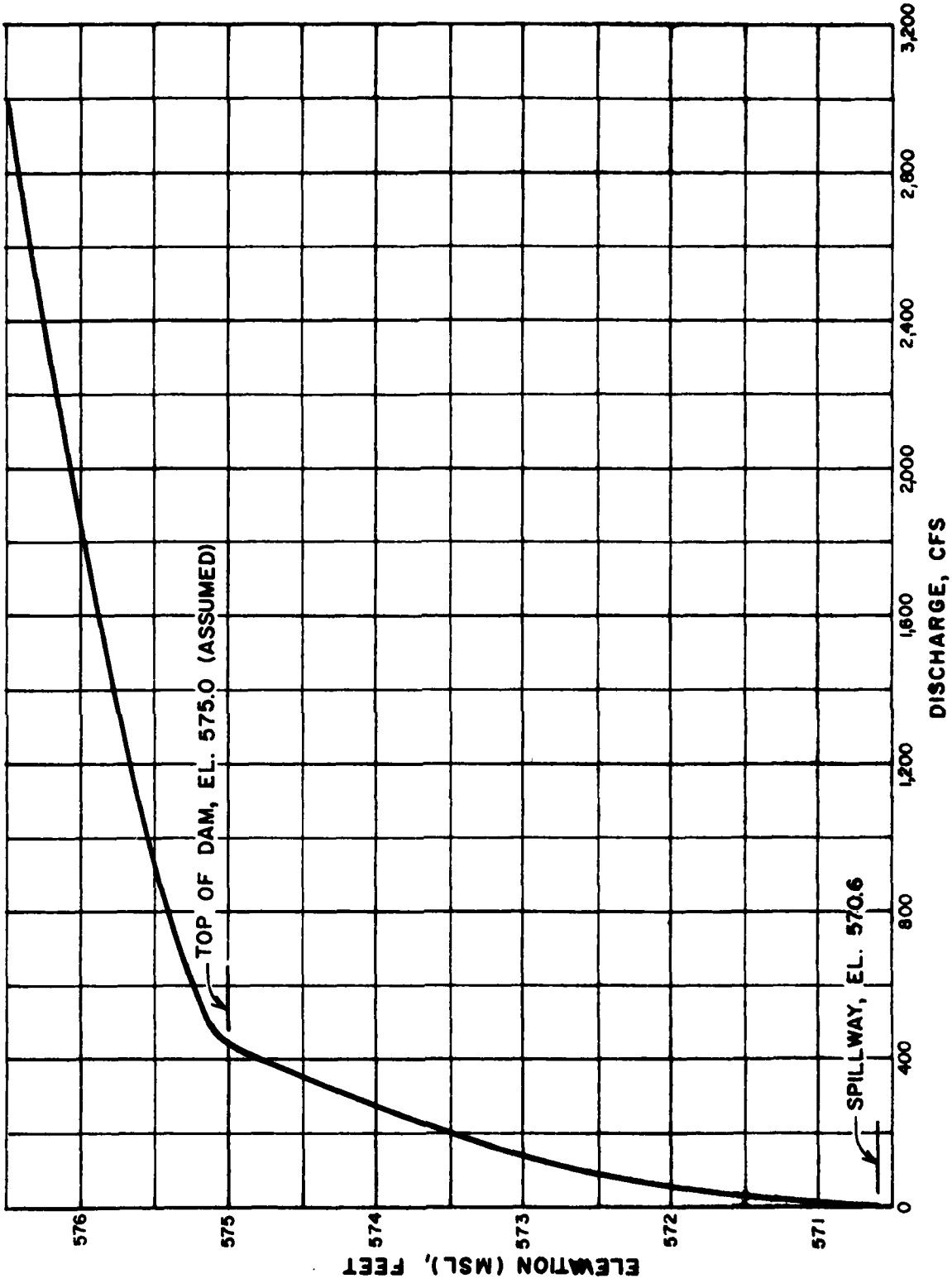
$\underline{y \geq 4.4}$ $A = 24(y-1)$, $P = 26.5$

$Q = 0.75\ A^{5/3}$

Q	y_c	y_N
21	0.5	0.497
119	1.5	1.4
280	2.5	2.2
531	3.4	3.1
813	4.5	3.9

Normal depth $y_N < y_c \Rightarrow$ the water surface will go through critical depth downstream of the dam and the assumption is adequate

PLATE 2, APPENDIX B



DR. HENSON LAKE DAM (MO. 31570)
SPILLWAY & OVERTOP RATING CURVE

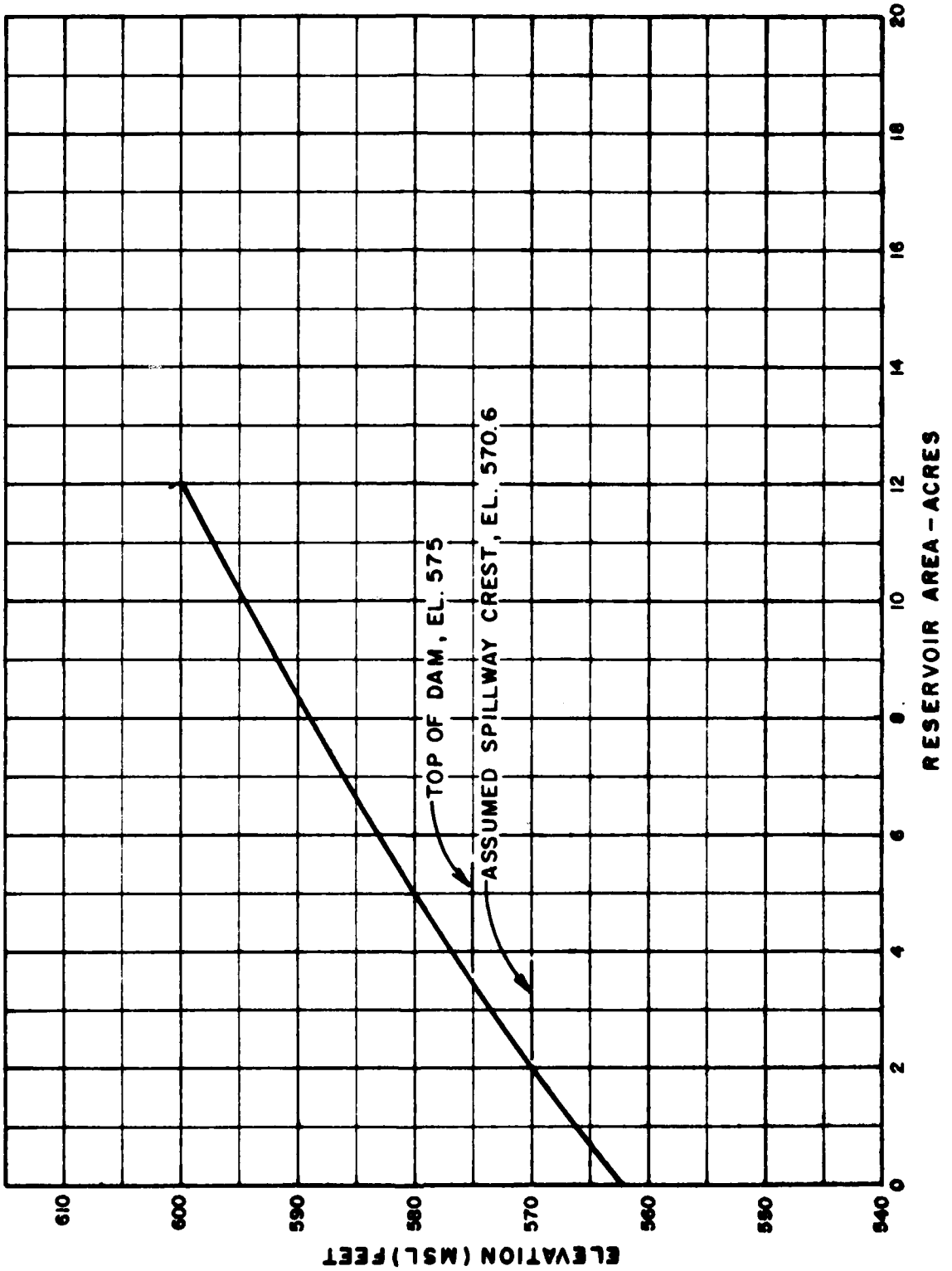
ECI-4 **PRC ENGINEERING CONSULTANTS, INC.**

DAM SAFETY INSPECTION - MISSOURI SHEET NO. 1 OF 1

DAM NAME: DT. HENSON LAKE DAM / ID NO.: 31570 JOB NO. 1263

RESERVOIR ELEVATION - AREA DATA BY JFK & FC DATE 4/21/80

ELEV. (M.S.L.) (Ft.)	RESERVOIR SURFACE AREA (Acres)	REMARKS
563.6	0	Assumed Bottom of Reservoir
570.6	2.0	Spillway elevation
580	5.0	Estimate from USGS Topo Map.
600	12.0	" " " "
590	8.3	Interpolated



DR. HENSON LAKE DAM (MO. 31570)
RESERVOIR ELEVATION-AREA CURVE

ECI-4 **PRC ENGINEERING CONSULTANTS, INC.**

DAM SAFETY INSPECTION / MISSOURI — SHEET NO. 1 OF 3

DAM NAME: DR. HENSON LAKE DAM NO 31570 — JOB NO. 126T

PROBABLE MAXIMUM PRECIPITATION — BY FZ DATE MAY 80

DETERMINATION OF PMP

1) Determine drainage area of the basin

D.A. = 0.089 sqmile

2) Determine PMP Index Rainfall (for D.A. = 200 sq. mi. & 24 hr duration)

Location of centroid of basin,

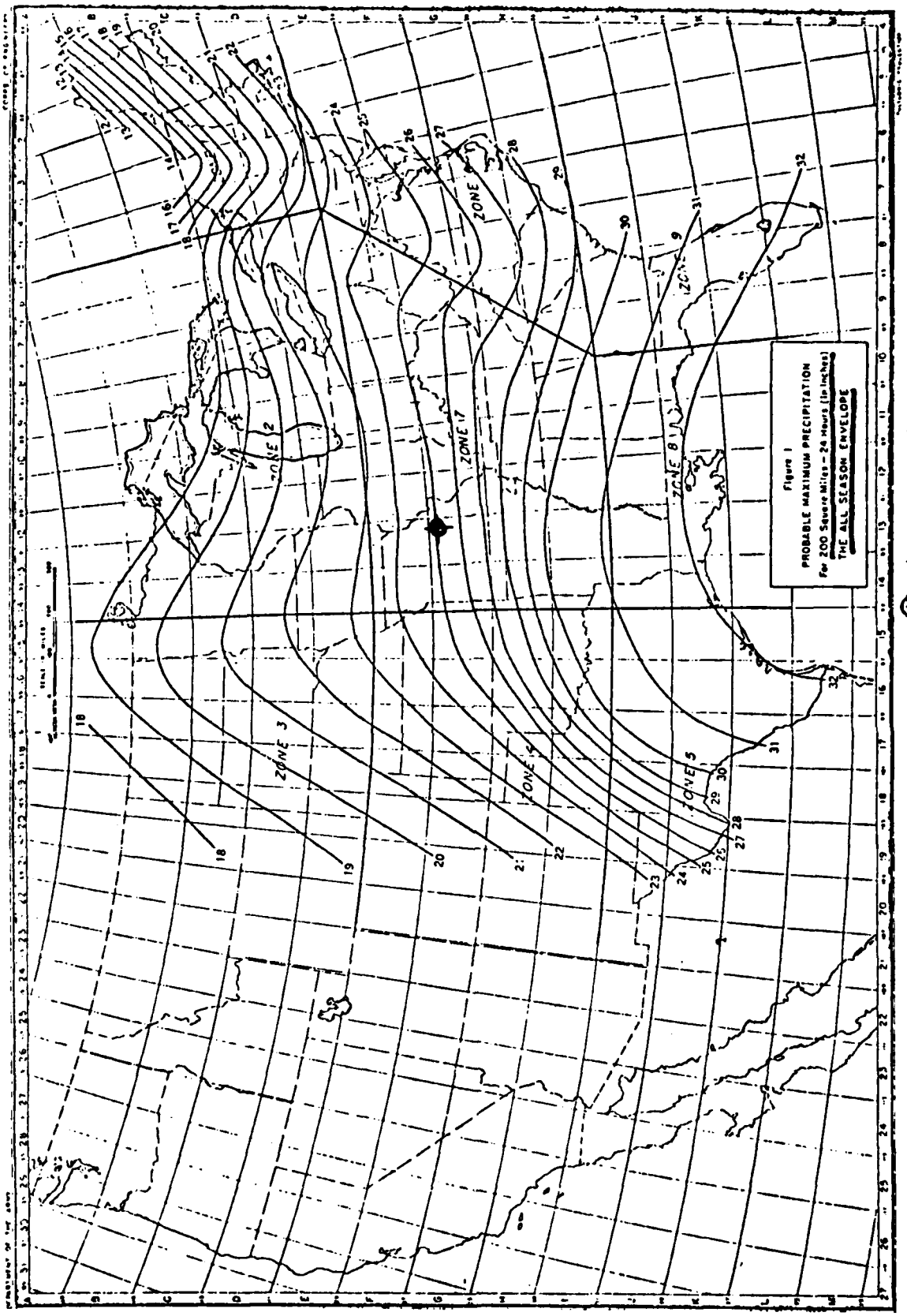
Long. = 91°27'16" Lat. = 38°41'54"

PMP = 25" (from Fig. 1, HMR 33)

Zone = 7

3) Determine basin rainfall in terms of percentage of PMP Index Rainfall for various durations. (from Fig. 2, HMR 33)

Duration (Hrs.)	Percent of Index Rainfall (%)	Total Rainfall (Inches)	Rainfall Increments (Inches)	Duration of Increment (Hrs.)
6	100	25	25	6
12	120	30	5	6
24	130	32.5	2.5	12



⊕ LOCATION OF DAM

DR. HENSON LAKE DAM
DETERMINATION OF PMP

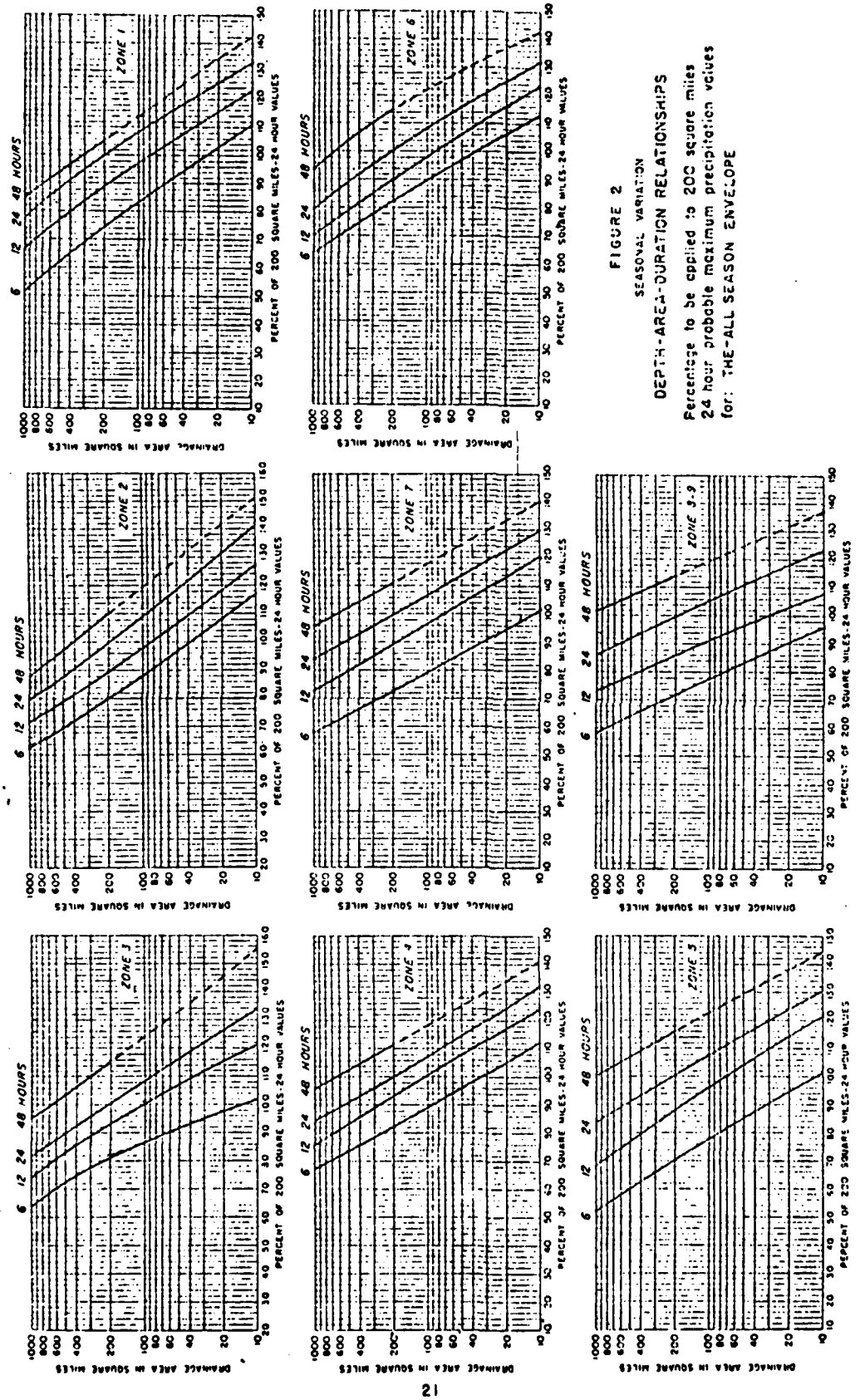


FIGURE 2

SEASONAL VARIATION

DEPTH-AREA-DURATION RELATIONSHIPS

Percentage to be applied to 200 square miles
24 hour probable maximum precipitation values
for: THE-ALL SEASON ENVELOPE

ECI-4 **PRC ENGINEERING CONSULTANTS, INC.**

DAM SAFETY INSPECTION / MISSOURI — SHEET NO. 1 OF 1

DAM NAME: DR. HENSON LAKE DAM # 31570 — JOB NO. 1263

UNIT HYDROGRAPH PARAMETERS — BY FZ DATE May 80

1) DRAINAGE AREA, $A = 0.089$ sq. mi. = (57 acres)

2) LENGTH OF STREAM, $L = (0.85'' \times 2000' = 1700') = 0.32$ mi.

3) ELEVATION AT DRAINAGE DIVIDE ALONG THE LONGEST STREAM,

$H_1 = 810$

4) ELEVATION OF RESERVOIR AT SPILLWAY CREST, $H_2 = 570.6$

5) ELEVATION OF CHANNEL BED AT 0.85L, $E_{85} = 740$

6) ELEVATION OF CHANNEL BED AT 0.10L, $E_{10} = 577$

7) AVERAGE SLOPE OF THE CHANNEL, $S_{AVG} = (E_{85} - E_{10})/0.75L = 0.13$

8) TIME OF CONCENTRATION:

A) BY KIRPICH'S EQUATION,

$$t_c = [(11.9 \times L^3)/(H_1 - H_2)]^{0.385} = [[11.9 \times 0.32^3)/(810 - 570.6)]^{0.385}$$
$$= 0.084 \text{ hr}$$

B) BY VELOCITY ESTIMATE,

SLOPE = 13% ⇒ AVG. VELOCITY = 5 fps.

$$t_c = L/V = \frac{1700}{5} \times \frac{1}{3600} = 0.094 \text{ hr}$$

USE $t_c = 0.084$ hr

9) LAG TIME, $t_l = 0.6\, t_c = 0.05$

10) UNIT DURATION, $D \leq t_l/3 = 0.017$ < 0.083 hr.

USE $D = 0.083$

11) TIME TO PEAK, $T_p = D/2 + t_l = \frac{0.083}{2} + 0.05 = 0.0915$

12) PEAK DISCHARGE,

$$q_p = (484 \times A)/T_p = \frac{484 \times 0.089}{0.0915} = 471 \text{ cfs}$$

ECI-4 **PRC ENGINEERING CONSULTANTS, INC.**

DAM SAFETY INSPECTION / MISSOURI - 1980 SHEET NO. 1 OF 1

DAM NAME: DR. HENSON LAKE DAM # 31570 JOB NO. 1263

CURVE NUMBER DETERMINATION BY PZ DATE MAY 80

I) SOIL GROUP

WATERSHED SOILS IN THE BASIN CONSIST OF GROUP A. (B) (C) D

MENFRO + WINFIELD

GROUP C SOILS SEEM TO PREDOMINATE THE BASIN. THEREFORE, ASSUME GROUP C SOILS FOR THE ENTIRE WATERSHED FOR HYDROLOGIC PURPOSES.

II) COVER COMPLEX

ASSUMED LAND USE	ASSUMED HYDROLOGIC CONDITION	PER CENT AREA	CN (AMC II)
WOODS	FAIR	47	73
RANGE	FAIR	53	79

III) CURVE NUMBER

WEIGHTED AVERAGE CN = 76 FOR AMC II

CURVE NUMBER = 89 FOR AMC III

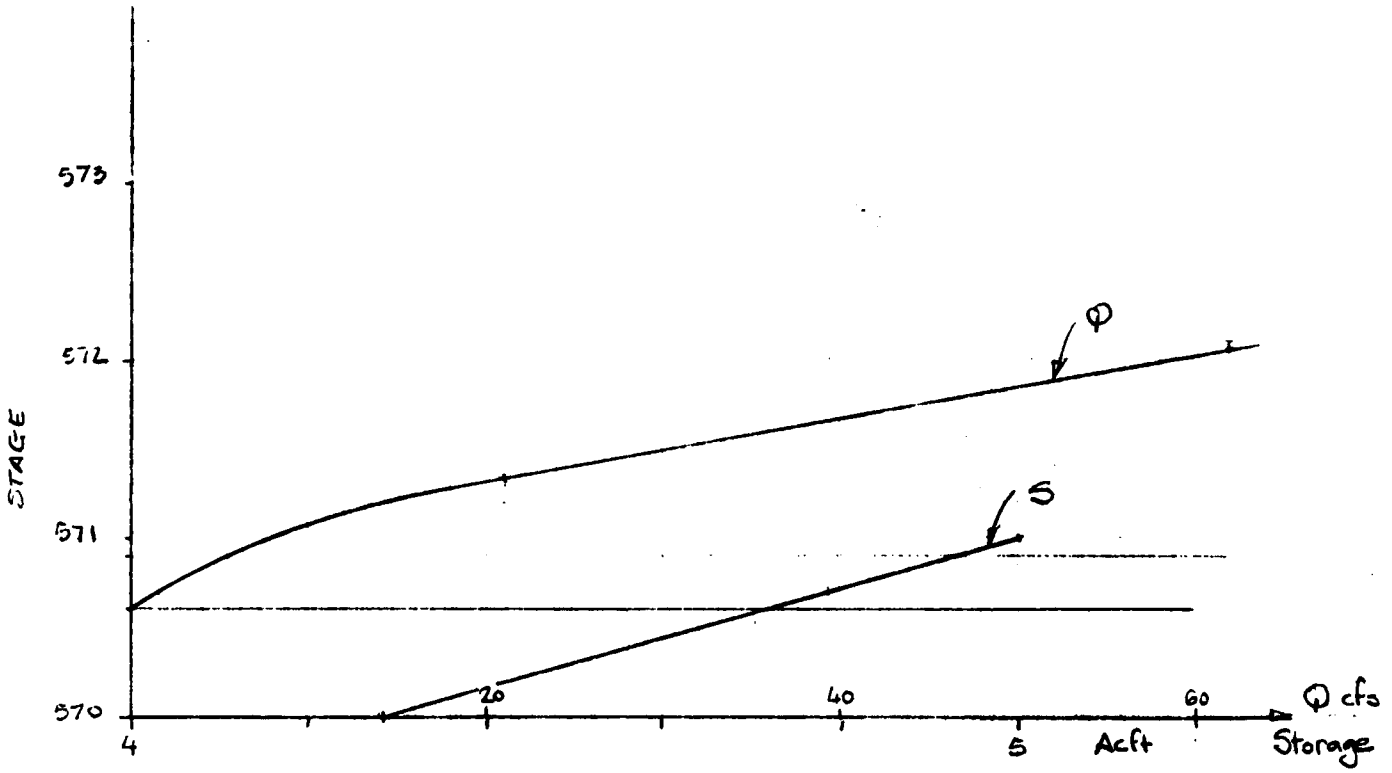
ECI-4 **PRC ENGINEERING CONSULTANTS, INC.**

SHEET NO. 1 OF 1

DAM SAFETY — JOB NO. 1263

DR NEWCON LAKE DAM — BY FZ DATE Sept 80

1/2 PMF antecedent storm is at 570.9 after 24 hrs



S	Q	Δt	ΣΔt	Time in days
4.44	5.5		1	
4.86	3.0	0.01	1.01	
4.78	1.5	0.02	1.03	
4.72	0	0.04	1.07	< 4 days OK

HECIDB INPUT DATA

```
*************************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION        JULY 1978
  LAST MODIFICATION    FEB 79
*************************************

                              DAM SAFETY INSPECTION - MISSOURI
                              DR. HENSON LAKE DAM(MO. 31570)
                                PMF AND FIFTY PERCENT PMF
          300    0     5                     0     0     0     0     0
               5
               1           1
                    .5
     K     HC31570                                     1
     K1    INPUT PRECIPITATION INDEX, RATIOS, AND UNIT HYDROGRAPH PARAMETERS.
           1     2    .289                .289      1                    1
                 25    130    120    130
     T                                                   -1     -89
          .05
                               1
     K  1  MO31570                                       1
     K1    ROUTE HYDROGRAPH THROUGH DR. HENSON LAKE DAM (NO. 31570)
                                     1      1
        1                                              -573.6    -1
     Y4 573.62  573.83  573.94  573.72  573.40  574.06  574.72  574.98  575.25  575.51
     Y4 574.77  574.22  576.75
     Y5     0      21     43     118    192     360     385     431     528     971
     Y6  1405   1894    3654
     $A          2       5       13      12
     $E 563.6   573.6    560     590     600
     $$ 573.4
     $D  575
         99
```

INFLOW PIF AND ONE-HALF PMF HYDROGRAPHS

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT 021570
ROUTE HYDROGRAPH TO 031570
END OF NETWORK

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION    JULY 1978
  LAST MODIFICATION  26 FEB 79
**********************************

RUN DATE= 80/09/16.
    TIME= 09.31.10.


                    DAM SAFETY INSPECTION - MISSOURI
                 DR. HENSON LAKE DAM(MO. 31570)
                    PMF AND FIFTY PERCENT PMF
                         JOB SPECIFICATION
      NO    NHR   NMIN   IDAY   IHR   IMIN  METRC   IPLT   IPRT  NSTAN
     300      0      5      0     0      0      0      0      0      0
                         JOPER   NWT  LROPT  TRACE
                             5     0      0      0

                  MULTI-PLAN ANALYSES TO BE PERFORMED
                    NPLAN= 1 NRTIO= 2 LRTIO= 1
         RTIOS=  1.00    .50

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

                     SUB-AREA RUNOFF COMPUTATION

        INPUT PRECIPITATION INDEX, RATIOS, AND UNIT HYDROGRAPH PARAMETERS,

                ISTAQ  ICOMP  IECON  ITAPE   JPLT   JPRT  INAME ISTAGE  IAUTO
               031570     0      0      0      0      0      1      0      0
                                  HYDROGRAPH DATA
         IHYDG   IUHG  TAREA   SNAP  TRSDA  TRSPC  RATIO  ISNOW  ISAME  LOCAL
             1      2    .09   0.00    .09   1.00  1.000      0      1      0
                                  PRECIP DATA
               SPFE    PMS     R6    R12    R24    R48    R72    R96
               0.00  25.00 100.00 120.00 130.00   0.00   0.00   0.00
                                  LOSS DATA
        LROPT  STRKR  DLTKR  RTIOL  ERAIN  STRKS  RTIOK  STRTL  CNSTL  ALSMX  RTIMP
            0   0.00   0.00   1.00   0.00   0.00   1.00  -1.00 -89.00   0.00   0.00

           CURVE NO = -89.00  WETNESS = -1.00  EFFECT CN =  89.00

                            UNIT HYDROGRAPH DATA
                        TC=  0.00     LAG=   .05

                              RECESSION DATA
                  STRTQ=  0.00    QRCSN=   0.00    RTIOR= 1.00
         TIME INCREMENT TOO LARGE--(NHQ IS GT LAG/2)

      UNIT HYDROGRAPH 18 END OF PERIOD ORDINATES, TC=   0.00 HOURS, LAG=   .05  VOL= 1.00
```

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	0.	1.01	12.35	151	.21	.20	.00	140.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.40	152	.21	.20	.00	140.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.45	153	.21	.20	.00	141.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.50	154	.21	.20	.00	141.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.55	155	.21	.20	.00	141.
1.01	.30	6	.01	0.00	.01	0.	1.01	13.00	156	.21	.20	.00	141.
1.01	.35	7	.01	0.00	.01	0.	1.01	13.05	157	.25	.25	.00	160.
1.01	.40	8	.01	0.00	.01	0.	1.01	13.10	158	.25	.25	.00	147.
1.01	.45	9	.01	0.00	.01	0.	1.01	13.15	159	.25	.25	.00	149.
1.01	.50	10	.01	0.00	.01	0.	1.01	13.20	160	.25	.25	.00	170.
1.01	.55	11	.01	0.00	.01	0.	1.01	13.25	161	.25	.25	.00	170.
1.01	1.00	12	.01	0.00	.01	0.	1.01	13.30	162	.25	.25	.00	170.
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.35	163	.25	.25	.00	170.
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.40	164	.25	.25	.00	170.
1.01	1.15	15	.01	0.00	.01	0.	1.01	13.45	165	.25	.25	.00	170.
1.01	1.20	16	.01	0.00	.01	0.	1.01	13.50	166	.25	.25	.00	170.
1.01	1.25	17	.01	.00	.01	0.	1.01	13.55	167	.25	.25	.00	170.
1.01	1.30	18	.01	.00	.01	0.	1.01	14.00	168	.25	.25	.00	170.
1.01	1.35	19	.01	.00	.01	0.	1.01	14.05	169	.31	.31	.00	199.
1.01	1.40	20	.01	.00	.01	0.	1.01	14.10	170	.31	.31	.00	210.
1.01	1.45	21	.01	.00	.01	0.	1.01	14.15	171	.31	.31	.00	213.
1.01	1.50	22	.01	.00	.01	1.	1.01	14.20	172	.31	.31	.00	213.
1.01	1.55	23	.01	.00	.01	1.	1.01	14.25	173	.31	.31	.00	214.
1.01	2.00	24	.01	.00	.01	1.	1.01	14.30	174	.31	.31	.00	214.
1.01	2.05	25	.01	.00	.01	1.	1.01	14.35	175	.31	.31	.00	214.
1.01	2.10	26	.01	.00	.01	1.	1.01	14.40	176	.31	.31	.00	214.
1.01	2.15	27	.01	.00	.01	2.	1.01	14.45	177	.31	.31	.00	214.
1.01	2.20	28	.01	.00	.01	2.	1.01	14.50	178	.31	.31	.00	214.
1.01	2.25	29	.01	.00	.01	2.	1.01	14.55	179	.31	.31	.00	214.
1.01	2.30	30	.01	.00	.01	2.	1.01	15.00	180	.31	.31	.00	214.
1.01	2.35	31	.01	.00	.01	2.	1.01	15.05	181	.19	.19	.00	158.
1.01	2.40	32	.01	.00	.01	2.	1.01	15.10	182	.38	.38	.00	224.
1.01	2.45	33	.01	.00	.01	2.	1.01	15.15	183	.38	.38	.00	252.
1.01	2.50	34	.01	.00	.01	3.	1.01	15.20	184	.57	.57	.00	385.
1.01	2.55	35	.01	.00	.01	3.	1.01	15.25	185	.67	.66	.00	424.
1.01	3.00	36	.01	.00	.01	3.	1.01	15.30	186	1.62	1.61	.01	685.
1.01	3.05	37	.01	.00	.01	3.	1.01	15.35	187	2.65	2.65	.01	1557.
1.01	3.10	38	.01	.00	.01	3.	1.01	15.40	188	1.05	1.04	.00	1020.
1.01	3.15	39	.01	.00	.01	3.	1.01	15.45	189	.67	.66	.00	614.
1.01	3.20	40	.01	.00	.01	3.	1.01	15.50	190	.57	.57	.00	449.
1.01	3.25	41	.01	.01	.01	3.	1.01	15.55	191	.38	.38	.00	317.
1.01	3.30	42	.01	.01	.01	4.	1.01	16.00	192	.38	.38	.00	273.
1.01	3.35	43	.01	.01	.01	4.	1.01	16.05	193	.29	.29	.00	223.
1.01	3.40	44	.01	.01	.01	4.	1.01	16.10	194	.29	.29	.00	225.
1.01	3.45	45	.01	.01	.01	4.	1.01	16.15	195	.29	.29	.00	201.
1.01	3.50	46	.01	.01	.01	4.	1.01	16.20	196	.29	.29	.00	201.
1.01	3.55	47	.01	.01	.01	4.	1.01	16.25	197	.29	.29	.00	208.
1.01	4.00	48	.01	.01	.01	4.	1.01	16.30	198	.29	.29	.00	201.
1.01	4.05	49	.01	.01	.01	4.	1.01	16.35	199	.29	.29	.00	201.
1.01	4.10	50	.01	.01	.01	4.	1.01	16.40	200	.29	.29	.00	201.
1.01	4.15	51	.01	.01	.01	4.	1.01	16.45	201	.29	.29	.00	201.
1.01	4.20	52	.01	.01	.01	4.	1.01	16.50	202	.29	.29	.00	201.
1.01	4.25	53	.01	.01	.01	5.	1.01	16.55	203	.29	.29	.00	201.
1.01	4.30	54	.01	.01	.01	5.	1.01	17.00	204	.29	.29	.00	201.
1.01	4.35	55	.01	.01	.01	5.	1.01	17.05	205	.23	.23	.00	172.

1.01	4.40	56	.01	.01	.01	56.	1.01	17.10	208	.03	.03	.00	16.
1.01	4.45	57	.01	.01	.01	57.	1.01	17.15	207	.03	.03	.00	16.
1.01	4.50	58	.01	.01	.01	58.	1.01	17.20	208	.03	.03	.00	16.
1.01	4.55	59	.01	.01	.01	59.	1.01	17.25	209	.03	.03	.00	16.
1.01	5.00	60	.01	.01	.01	60.	1.01	17.30	210	.03	.03	.00	16.
1.01	5.05	61	.01	.01	.01	61.	1.01	17.35	211	.03	.03	.00	16.
1.01	5.10	62	.01	.01	.01	62.	1.01	17.40	212	.03	.03	.00	16.
1.01	5.15	63	.01	.01	.01	63.	1.01	17.45	213	.03	.03	.00	16.
1.01	5.20	64	.01	.01	.01	64.	1.01	17.50	214	.03	.03	.00	16.
1.01	5.25	65	.01	.01	.01	65.	1.01	17.55	215	.03	.03	.00	16.
1.01	5.30	66	.01	.01	.01	66.	1.01	18.00	216	.03	.03	.00	16.
1.01	5.35	67	.01	.01	.01	67.	1.01	18.05	217	.02	.02	.00	60.
1.01	5.40	68	.01	.01	.01	68.	1.01	18.10	218	.02	.02	.00	55.
1.02	5.45	69	.01	.01	.01	69.	1.01	18.15	219	.02	.02	.00	17.
1.01	5.50	70	.01	.01	.01	70.	1.01	18.20	220	.02	.02	.00	14.
1.01	5.55	71	.01	.01	.01	71.	1.01	18.25	221	.02	.02	.00	14.
1.01	6.00	72	.01	.01	.01	72.	1.01	18.30	222	.02	.02	.00	14.
1.01	6.05	73	.07	.06	.01	73.	1.01	18.35	223	.02	.02	.00	14.
1.01	6.10	74	.07	.06	.02	74.	1.01	18.40	224	.02	.02	.00	14.
1.01	6.15	75	.07	.05	.02	75.	1.01	18.45	225	.02	.02	.00	14.
1.01	6.20	76	.07	.05	.02	76.	1.01	18.50	226	.02	.02	.00	14.
1.01	6.25	77	.07	.05	.02	77.	1.01	18.55	227	.02	.02	.00	14.
1.01	6.30	78	.07	.05	.02	78.	1.01	19.00	228	.02	.02	.00	14.
1.01	6.35	79	.07	.05	.02	79.	1.01	19.05	229	.02	.02	.00	14.
1.01	6.40	80	.07	.05	.02	80.	1.01	19.10	230	.02	.02	.00	14.
1.01	6.45	81	.07	.05	.02	81.	1.01	19.15	231	.02	.02	.00	14.
1.01	6.50	82	.07	.05	.02	82.	1.01	19.20	232	.02	.02	.00	14.
1.01	6.55	83	.07	.05	.01	83.	1.01	19.25	233	.02	.02	.00	14.
1.01	7.00	84	.07	.05	.01	84.	1.01	19.30	234	.02	.02	.00	14.
1.01	7.05	85	.07	.05	.01	85.	1.01	19.35	235	.02	.02	.00	14.
1.01	7.10	86	.07	.06	.01	86.	1.01	19.40	236	.02	.02	.00	14.
1.01	7.15	87	.07	.06	.01	87.	1.01	19.45	237	.02	.02	.00	14.
1.01	7.20	88	.07	.06	.01	88.	1.01	19.50	238	.02	.02	.00	14.
1.01	7.25	89	.07	.06	.01	89.	1.01	19.55	239	.02	.02	.00	14.
1.01	7.30	90	.07	.06	.01	90.	1.01	20.00	240	.02	.02	.00	14.
1.01	7.35	91	.07	.06	.01	91.	1.01	20.05	241	.02	.02	.00	14.
1.01	7.40	92	.07	.06	.01	92.	1.01	20.10	242	.02	.02	.00	14.
1.01	7.45	93	.07	.06	.01	93.	1.01	20.15	243	.02	.02	.00	14.
1.01	7.50	94	.07	.06	.01	94.	1.01	20.20	244	.02	.02	.00	14.
1.01	7.55	95	.07	.06	.01	95.	1.01	20.25	245	.02	.02	.00	14.
1.01	8.00	96	.07	.06	.01	96.	1.01	20.30	246	.02	.02	.00	14.
1.01	8.05	97	.07	.06	.01	97.	1.01	20.35	247	.02	.02	.00	14.
1.01	8.10	98	.07	.06	.01	98.	1.01	20.40	248	.02	.02	.00	14.
1.01	8.15	99	.07	.06	.01	99.	1.01	20.45	249	.02	.02	.00	14.
1.01	8.20	100	.07	.06	.01	100.	1.01	20.50	250	.02	.02	.00	14.
1.01	8.25	101	.07	.06	.01	101.	1.01	20.55	251	.02	.02	.00	14.
1.01	8.30	102	.07	.06	.01	102.	1.01	21.00	252	.02	.02	.00	14.
1.01	8.35	103	.07	.06	.01	103.	1.01	21.05	253	.02	.02	.00	14.
1.01	8.40	104	.07	.06	.01	104.	1.01	21.10	254	.02	.02	.00	14.
1.01	8.45	105	.07	.06	.01	105.	1.01	21.15	255	.02	.02	.00	14.
1.01	8.50	106	.07	.06	.01	106.	1.01	21.20	256	.02	.02	.00	14.
1.01	8.55	107	.07	.06	.01	107.	1.01	21.25	257	.02	.02	.00	14.
1.01	9.00	108	.07	.06	.01	108.	1.01	21.30	258	.02	.02	.00	14.
1.01	9.05	109	.07	.06	.01	109.	1.01	21.35	259	.02	.02	.00	14.
1.01	9.10	110	.07	.06	.01	110.	1.01	21.40	260	.02	.02	.00	14.
1.01	9.15	111	.07	.06	.00	111.	1.01	21.45	261	.02	.02	.00	14.
1.01	9.20	112	.07	.06	.00	112.	1.01	21.50	262	.02	.02	.00	14.
1.01	9.25	113	.07	.06	.00	113.	1.01	21.55	263	.02	.02	.00	14.
1.01	9.30	114	.07	.06	.00	114.	1.01	22.00	264	.02	.02	.00	14.
1.01	9.35	115	.07	.07	.00	115.	1.01	22.05	265	.02	.02	.00	14.

43.	43.	43.	44.	44.	44.	44.	44.	44.	44.
44.	45.	45.	45.	45.	45.	45.	45.	45.	45.
45.	45.	45.	45.	46.	46.	46.	46.	46.	46.
45.	46.	46.	46.	46.	46.	46.	46.	46.	46.
46.	46.	46.	46.	[illegible]	132.	138.	139.	140.	140.
140.	140.	141.	141.	[illegible]	141.	166.	167.	169.	170.
170.	170.	170.	170.	170.	170.	170.	170.	199.	210.
213.	213.	214.	214.	214.	214.	214.	214.	214.	219.
[illegible]	224.	252.	346.	474.	685.	1537.	1020.	614.	449.
317.	273.	223.	[illegible]	211.	201.	200.	201.	201.	201.
201.	201.	201.	201.	172.	161.	158.	158.	158.	158.
[illegible]	158.	155.	174.	155.	155.	62.	25.	17.	15.
14.	14.	14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.	5.	1.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1557.	237.	74.	71.	21397.
CMS	44.	7.	2.	2.	606.
INCHES		24.73	31.06	31.06	31.06
MM		628.15	788.99	788.99	788.99
AC-FT		117.	147.	147.	147.
THOUS CU M		144.	182.	182.	182.

HYDROGRAPH AT STA021575 FOR PLAN 1, RTIO 1

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	11.	14.	16.	16.	17.	17.	18.	18.
19.	19.	19.	19.	19.	20.	20.	20.	20.	20.
21.	21.	21.	21.	21.	21.	21.	21.	21.	21.
22.	22.	22.	22.	22.	22.	22.	22.	22.	22.
22.	22.	22.	22.	22.	22.	22.	23.	23.	23.
23.	23.	23.	23.	23.	23.	23.	23.	23.	23.
23.	23.	23.	23.	23.	23.	23.	23.	23.	23.
23.	23.	23.	23.	54.	66.	69.	70.	70.	70.
70.	70.	70.	70.	70.	70.	90.	84.	95.	85.
85.	85.	85.	85.	85.	85.	95.	85.	100.	105.
107.	107.	107.	107.	107.	107.	107.	107.	107.	107.
79.	112.	126.	173.	212.	442.	769.	710.	397.	225.
159.	136.	111.	103.	101.	100.	100.	100.	100.	100.
100.	100.	100.	100.	86.	80.	79.	79.	79.	79.
79.	79.	79.	79.	79.	79.	33.	13.	8.	7.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.

PHF AND ONE-HALF PMF ROUTING

7.	7.	7.	7.	7.	7.	7.	7.	2.	1.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	769.	119.	37.	36.	10699.
CMS	22.	3.	1.	1.	303.
INCHES		12.36	15.53	15.53	15.53
MM		314.03	394.49	394.49	394.49
AC-FT		59.	74.	74.	74.
THOUS CU M		72.	91.	91.	91.

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

HYDROGRAPH ROUTING

ROUTE HYDROGRAPH THROUGH DR. HENSON LAKE DAM (NO. 31570)

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
031570	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP		LSTR
0.0	0.000	0.00	1	1	0	0		0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-571.	-1

STAGE	570.62	571.33	572.04	572.72	573.40	574.06	574.72	574.98	575.25	575.51
	575.77	576.02	576.75							
FLOW	0.00	21.00	62.00	113.00	192.00	290.00	[illegible]	431.00	629.00	971.00
	1405.00	1894.00	3654.00							

SURFACE AREA=	0.	2.	5.	8.	12.
CAPACITY=	0.	5.	37.	102.	203.
ELEVATION=	564.	571.	580.	590.	600.

CREL	SPWID	COQW	EXPW	ELEVL	COOL	CAREA	EXPL
570.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

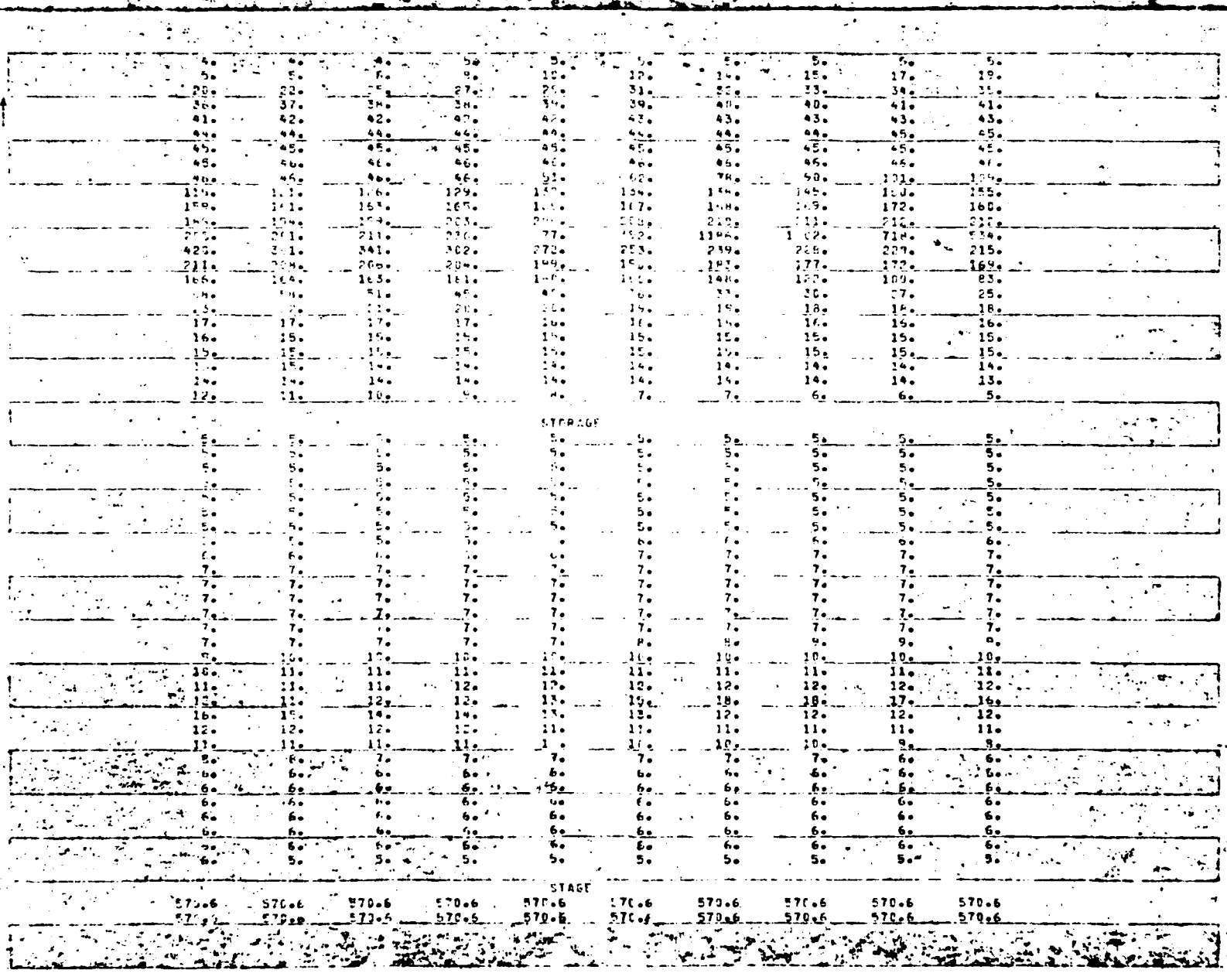
TOPEL	COQD	EXPD	DAMWID
575.0	0.0	0.0	0.

STATION 031570, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	1.	1.	1.	1.
1.	1.	1.	1.	1.	2.	2.	2.	2.	2.
2.	2.	2.	3.	3.	3.	3.	3.	3.	3.
3.	3.	4.	4.	4.	4.	4.	4.	4.	4.



STORAGE

STAGE

570.6 570.6 570.6 570.6 570.6 570.6 570.6 570.6 570.6 570.6

570.6	570.6	570.6	570.6	570.6	570.6	570.6	570.6	570.6	570.6
570.6	570.6	570.6	[illegible]	570.7	570.7	570.7	570.7	570.7	570.7
570.7	570.7	570.7	570.7	570.7	570.7	570.7	570.7	570.7	570.7
570.7	570.7	570.7	570.7	570.7	570.7	570.7	570.7	570.7	570.7
570.7	[illegible]	[illegible]	570.8	570.8	570.8	570.8	570.8	570.8	570.8
570.8	[illegible]	570.8	570.9	570.9	571.0	571.1	571.1	571.2	[illegible]
571.3	571.4	571.4	571.4	571.5	[illegible]	571.5	571.5	571.6	571.6
571.6	571.6	571.6	571.6	571.6	[illegible]	571.7	571.7	571.7	571.7
571.7	571.7	571.7	571.7	571.7	571.7	571.7	571.7	571.7	571.7
571.7	571.7	571.7	571.7	571.7	571.7	571.7	571.7	571.7	571.7
571.7	571.7	571.7	571.7	571.7	571.7	571.7	571.8	571.8	571.8
571.8	571.8	[illegible]	571.8	571.8	571.8	571.8	571.8	571.8	571.8
571.8	571.9	[illegible]	[illegible]	571.9	572.0	572.2	572.4	572.5	572.6
572.7	572.7	[illegible]	[illegible]	572.8	572.9	572.9	573.0	573.0	573.1
573.1	573.1	573.1	573.1	573.2	573.2	573.2	573.2	573.2	573.3
573.4	573.4	[illegible]	[illegible]	573.5	573.5	[illegible]	[illegible]	573.5	573.6
573.5	[illegible]	573.9	[illegible]	574.0	[illegible]	574.0	573.7	573.8	573.8
[illegible]	574.7	[illegible]	[illegible]	574.0	573.9	573.7	573.7	573.6	573.6
573.5	[illegible]	[illegible]	573.5	573.5	573.4	573.3	573.3	573.2	573.2
573.2	573.1	573.1	573.1	573.1	573.1	573.0	572.7	572.5	572.3
572.1	572.0	571.9	[illegible]	571.7	571.6	571.5	571.5	571.4	571.4
571.4	[illegible]	[illegible]	[illegible]	571.3	571.2	[illegible]	571.2	571.2	571.2
571.2	571.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	571.2	571.2	571.1
571.1	571.1	571.1	571.1	571.1	571.1	571.1	571.1	571.1	571.1
571.1	571.1	571.1	571.1	571.1	571.1	571.1	571.1	571.1	571.1
571.1	571.1	571.1	571.1	571.1	571.1	571.1	571.1	571.1	571.1
571.1	571.1	571.1	571.1	571.1	571.1	571.1	571.1	571.1	571.1
571.0	571.0	[illegible]	570.9	570.9	570.9	[illegible]	570.8	570.8	570.8

PEAK OUTFLOW IS 1332. AT TIME [illegible] HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1332.	[illegible]	74.	71.	21746.
CMS	37.	7.	2.	2.	604.
INCHES		[illegible]	30.99	30.99	30.99
MM		617.68	787.07	787.07	787.07
AC-FT		115.	147.	147.	147.
THOUS CU M		142.	181.	181.	181.

STATION 031570, PLAN 1, RATIO 2

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
3.	3.	[illegible]	4.	5.	6.	7.	8.	9.	10.
10.	11.	12.	12.	13.	14.	14.	15.	15.	16.
14.	16.	17.	17.	17.	18.	18.	18.	19.	19.
19.	19.	19.	20.	20.	20.	20.	20.	21.	21.
21.	21.	21.	21.	21.	22.	22.	22.	22.	22.
22.	22.	22.	22.	22.	22.	23.	23.	23.	23.

23.	23.	23.	23.	23.	23.	23.	23.	23.	23.
23.	23.	23.	23.	26.	31.	37.	42.	47.	50.
54.	56.	58.	60.	62.	64.	[illegible]	69.	72.	75.
77.	79.	80.	81.	82.	83.	83.	84.	85.	89.
92.	95.	98.	100.	101.	102.	103.	104.	105.	105.
103.	101.	105.	114.	132.	180.	298.	403.	404.	361.
310.	262.	224.	191.	170.	153.	140.	130.	123.	117.
134.	121.	109.	107.	104.	100.	96.	92.	69.	87.
85.	84.	83.	82.	81.	[illegible]	75.	64.	55.	48.
41.	36.	31.	27.	24.	21.	20.	19.	18.	17.
16.	15.	14.	14.	13.	13.	12.	12.	11.	11.
11.	10.	10.	10.	10.	9.	9.	9.	9.	9.
9.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	7.	7.	7.	7.	7.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
7.	7.	7.	7.	7.	7.	7.	7.	7.	6.
5.	5.	5.	4.	4.	4.	3.	3.	3.	2.
				STORAGE					
5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
6.	5.	6.	6.	6.	6.	6.	6.	6.	6.
6.	6.	6.	6.	6.	6.	6.	6.	6.	6.
6.	6.	6.	6.	6.	6.	6.	6.	6.	6.
6.	6.	6.	6.	6.	6.	6.	6.	6.	6.
6.	6.	6.	6.	6.	6.	6.	6.	6.	6.
6.	6.	5.	5.	6.	6.	6.	6.	6.	6.
6.	6.	6.	5.	6.	7.	7.	7.	7.	7.
7.	8.	8.	8.	8.	8.	9.	8.	8.	8.
8.	9.	9.	8.	8.	8.	8.	8.	8.	9.
9.	9.	9.	9.	9.	9.	9.	9.	9.	9.
9.	9.	9.	9.	10.	11.	14.	15.	16.	15.
14.	13.	12.	11.	11.	10.	10.	10.	10.	9.
9.	9.	9.	9.	9.	9.	9.	9.	9.	9.
8.	8.	8.	8.	8.	8.	8.	8.	8.	7.
7.	7.	7.	6.	6.	6.	6.	6.	6.	6.
5.	6.	6.	6.	6.	6.	6.	6.	5.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	6.
				STAGE					
570.6	570.6	570.6	570.6	570.6	570.6	570.6	570.6	570.6	570.6
570.6	570.6	570.6	570.6	570.6	570.6	570.6	570.6	570.6	570.6
570.6	570.6	570.6	570.6	570.6	570.6	570.6	570.6	570.6	570.6
570.6	570.6	570.6	570.6	570.6	570.6	570.6	570.6	570.6	570.6
570.6	570.6	570.6	570.6	570.6	570.6	570.7	570.7	570.7	570.7
570.7	570.7	570.7	570.7	570.7	570.7	570.7	570.7	570.7	570.7
570.7	570.7	570.7	570.7	570.7	570.7	570.7	570.7	570.7	570.7
570.7	570.7	570.7	570.7	570.8	570.8	570.8	570.9	570.9	570.9
571.0	571.0	571.0	571.0	571.1	571.1	571.1	571.1	571.1	571.1

571.2	571.2	571.2	571.2	571.2	571.2	571.2	571.2	571.2	571.3
571.3	571.3	571.3	571.3	571.3	571.3	571.3	571.3	571.3	571.3
571.3	571.3	571.3	571.3	571.3	571.3	571.3	571.3	571.3	571.3
571.4	571.4	571.4	571.4	571.4	571.4	571.4	571.4	571.4	571.4
571.4	571.4	571.4	571.4	571.4	571.4	571.4	571.4	571.4	571.4
571.4	571.4	571.4	571.4	571.4	571.5	571.6	571.7	571.8	571.8
571.9	571.9	572.0	572.0	572.0	572.1	572.1	572.1	572.2	572.2
572.2	572.2	572.3	572.3	572.3	572.3	572.3	572.3	572.3	572.4
572.4	572.4	572.5	572.5	572.5	572.5	572.5	572.5	572.5	572.6
572.5	572.6	572.6	572.7	572.6	573.3	574.2	574.8	574.8	574.6
574.2	573.9	573.6	573.4	573.2	573.0	572.9	572.8	572.8	572.7
572.7	572.6	572.6	572.5	572.5	572.4	572.4	572.4	572.4	572.3
572.3	572.3	572.3	572.3	572.3	572.3	572.2	572.1	571.9	571.8
571.7	571.6	571.5	571.4	571.4	571.3	571.3	571.3	571.2	571.2
571.2	571.1	571.1	571.1	571.1	571.0	571.0	571.0	571.0	571.0
571.0	571.0	570.9	570.9	570.9	570.9	570.9	570.9	570.9	570.9
570.9	570.9	570.9	570.9	570.9	570.9	570.9	570.9	570.9	570.9
570.9	570.9	570.9	570.9	570.9	570.9	570.9	570.9	570.9	570.9
570.8	570.8	570.8	570.9	570.9	570.9	570.9	570.8	570.8	570.8
570.9	570.8	570.8	570.8	570.8	570.8	570.8	570.8	570.8	570.8
570.8	570.8	570.8	570.8	570.7	570.7	570.7	570.7	570.7	570.7

PEAK OUTFLOW IS 404. AT TIME 15.75 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	404.	110.	37.	36.	10672.
CMS	11.	3.	1.	1.	302.
INCHES		1.09	1.49	1.49	1.49
MM		27.69	37.92	37.92	37.92
AC-FT		67.	74.	74.	74.
THOUS CU M		71.	91.	91.	91.

B-27

SUMMARY OF PMF AND ONE-HALF PMF FLOOD ROUTING

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

OPERATION	STATION	AREA	PLAN	RATIO 1 1.00	RATIO 2 .50
HYDROGRAPH AT	031570	.59	1	1537.	764.
	(	.23)	(	43.531)	21.703)
ROUTED TO	031573	.89	1	1302.	414.
	(	.23)	(	36.867)	11.844)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 **********

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	570.60	570.60	575.00
STORAGE	5.	5.	16.
OUTFLOW	0.	0.	446.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE (AC-FT)	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	575.71	.71	18.	1202.	.58	15.67	0.00
.50	574.85	0.00	16.	446.	0.00	15.75	0.00

PERCENT OF PMF FLOOD ROUTING
EQUAL TO SPILLWAY CAPACITY

```
***********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
 LAST MODIFICATION  26 FEB 79
***********************************
        1          A1                        DAM SAFETY INSPECTION - MISSOURI
        2          A2                      DR. HENSON LAKE DAM(MO. 31:70)
        3          A3                             PERCENT PMF
        4          B    300      0      5      0      0      0      0      0     -4      0
        5          B1     5
        6          J      1      4      1
        7          J1   .45    .50    .[illegible]    .60
        8          K            MO31570                                  1
        9          K1      INPUT PRECIPITATION INDEX, RATIOS, AND UNIT HYDROGRAPH PARAMETERS.
       10          M      1      2   .089           .089      1                    1
       11          P            26    100    120    122
       12          T                                                    -1     .89
       13          W2          .01
       14          K                     1
       15          K      1 MO31570                                  1
       16          K1      ROUTE HYDROGRAPH THROUGH DR. HENSON LAKE DAM (MO. 31:70)
       17          Y                                   1      1
       18          Y1     1                                      -57.6      -1
       19          Y4570.00 571.33 572.04 572.72 573.40 574.06 574.72 574.96 575.25 575.51
       20          Y4575.77 576.02 576.75
       21          Y5     0     21     62    119    192    260    385    431    629    971
       22          Y5  1405   1894   3654
       23          $A            1      5    6.3     17
       24          $E 563.6  570.0    580    590    600
       25          $$ 570.6
       26          $D   575
       27          K     99
```

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT ___ C31570
ROUTE HYDROGRAPH TO ___ C31570
END OF NETWORK

FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 26 FEB 79

RUN DATE= 85/09/16.
TIME= 09.25.02.

DAM SAFETY INSPECTION - MISSOURI
MR. HENSON LAKE DAM(MO. 31570)
PERCENT SMP

JOB SPECIFICATION

IO	ICHK	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	MSTAN
5	1	5	0	0	0	0	0	0	0

JOPER	NRT	LROPT	TRACE
	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 4 LRTIO= 1

RTIOS=	.45	.50	.55	.60

SUB-AREA RUNOFF COMPUTATION

INPUT PRECIPITATION INDEX, RATIOS, AND UNIT HYDROGRAPH PARAMETERS.

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
031570	0	0	0	0	0	1		0

HYDROGRAPH DATA

IHYDR	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ICAPE	LOCAL
1	2	.09	0.00	.09	1.00	0.000		1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.30	100.00	130.00	130.00	0.00	0.00	0.00

LOSS DATA

LROPT	STRKS	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-89.00	0.00	0.00

CURVE NO = -89.00 WETNESS = -1.00 EFFECT CN = 89.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .05

RECESSION DATA
STRTQ= 0.00 QRCSN= 0.00 RTIOR= 1.00

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q

```
                                                                        ISUM  32.50  31.06   1.44    21312.
                                                                            ( 825.)( 789.)( 37.)( 585.71)

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

                                           HYDROGRAPH ROUTING

                        ROUTE HYDROGRAPH THROUGH D.. HENSON LAKE DAM (NO. 31570)

                                 ISTAG   ICOMP   IECON   ITAPE   JPLT   JPRT   INAME  ISTAGE  IAUTO
                                 31570       1       0       0      0      0       1       0      0
                                                      ROUTING DATA
                          QLOSS  CLOSS     AVG   IRES   ISAME   IOPT   IPMP          LSTR
                            0.0  0.000    0.00      1       1      0      0             0

                                  NSTPS  NSTDL     LAG  AMSKK      X     TSK  STORA  ISPRAT
                                      1      0       0  0.000  0.000  0.000  -571.     -1

      STAGE      571.00    571.44    571.04    572.72    573.41    574.06    574.72    574.98    575.25    575.51
                 575.77    576.03    576.79

       FLOW        0.00     21.00     62.00    119.00    192.00    269.00    355.00    431.00    629.00    971.00
                1405.00   1914.00   3604.00

    SURFACE AREA=      0.        1.        5.        8.       12.

      CAPACITY=        0.        5.       37.      100.      207.

     ELEVATION=      564.      571.      580.      590.      600.

                             CREL    SPWID   COQW   EXPW   ELEVL   COOL   CAREA   EXPL
                            575.6     0.0     0.0    0.0     0.0    0.0     0.0    0.0

                                                     DAM DATA
                                          TOPEL    COQD    EXPD  DAMWID
                                          575.0     0.0     0.0     0.

   PEAK OUTFLOW IS      359. AT TIME  15.75 HOURS

   PEAK OUTFLOW IS      494. AT TIME  15.75 HOURS

   PEAK OUTFLOW IS      462. AT TIME  15.67 HOURS

   PEAK OUTFLOW IS      608. AT TIME  15.67 HOURS

           **********          **********          **********          **********          **********
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AD-A106 623 PRC CONSOER TOWNSEND INC ST LOUIS MO F/G 13/13
NATIONAL DAM SAFETY PROGRAM. DR. HENSON LAKE DAM (MO 31570), MI--ETC(U)
SEP 80 W G SWIFRIN DACW43-80-C-0094
UNCLASSIFIED NL

2 of 2

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

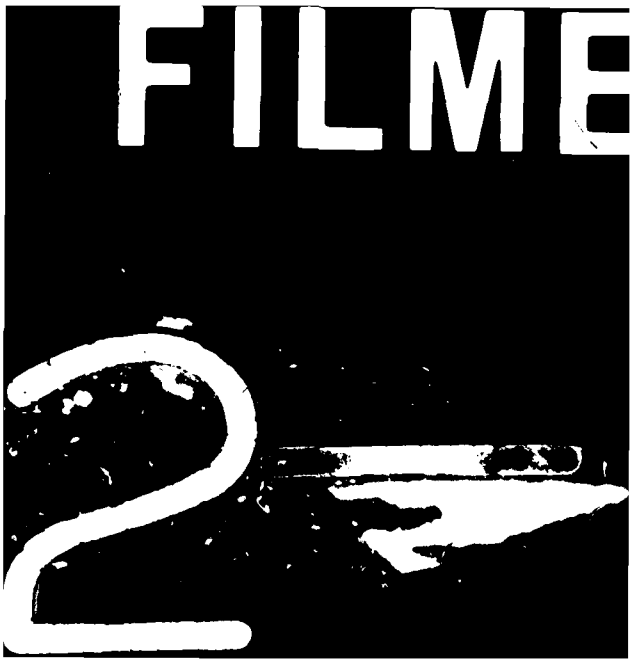
OPERATION	STATION	AREA	PLAN	RATIO 1 .45	RATIO 2 .50	RATIO 3 .55	RATIO 4 .60
HYDROGRAPH AT	03157)	.09 (.23)	1	690. (19.59)(	769. (21.74)(	845. (23.94)(	92[illegible]. (26.12)(
ROUTED TO	03157)	.09 (.23)	1	3[illegible]. (10.19)(	414. (11.44)(	4[illegible]. (13.69)(	60[illegible]. (17.2[illegible])(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ..... INITIAL VALUE | SPILLWAY CREST | TOP OF DAM

	ELEVATION	570.00	570.00	575.00
	STORAGE	0.	0.	16.
	OUTFLOW	0.	0.	446.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE (AC-FT)	MAXIMUM OUTFLOW (CFS)	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.40	74.56	.01	15.	155.	0.00	15.75	0.00
.50	74.83	0.00	15.	434.	0.00	15.75	0.00
.55	74.91	.01	15.	582.	.17	15.67	0.00
.60	75.22	.02	17.	808.	.17	15.67	0.00


FILME