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NATIONAL DAM INSPECTION PROGRAM. HAWSTONE DAM, (NDI NUMBER PA-C--ETC(U)
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NATIONAL BUREAU OF CRIMINAL INVESTIGATION

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PREFACE

A

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D. C. 20314. 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 condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface 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.

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.

It is important to note that the condition of a 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 frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition, and the downstream damage potential.

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

ABSTRACT

Hawstone Dam: NDI I.D. No. PA-00580

Owner: John Hostetter
State Located: Pennsylvania (PennDER I.D. No. 44-7)
County Located: Mifflin
Stream: Unnamed Tributary to the Juniata River
Inspection Date: 26 November 1979
Inspection Team: GAI Consultants, Inc.
570 Beatty Road
Monroeville, Pennsylvania 15146

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Based on a visual inspection, operational history, and available engineering data, the dam is considered to be in poor condition.

Deficiencies noted by the inspection team include: a) an overall lack of maintenance, b) spalled and delaminated concrete surfaces along both faces of the dam, c) leakage through the downstream dam face, d) extensive cracking of the spillway structure and, e) lack of drawdown capability.

The size classification of the facility is small and its hazard classification is considered to be significant. In accordance with the recommended guidelines, the range of the Spillway Design Flood (SDF) for the facility is the 100-year Flood to the 1/2 PMF (Probable Maximum Flood). Due to the potential for loss of life from sudden failure of the dam, the SDF is considered to be the 1/2 PMF. Results of the hydrologic and hydraulic analysis indicate the facility will pass and/or store about 39 percent of the PMF prior to dam overtopping. Thus, based on criteria contained in the recommended guidelines, the spillway is considered inadequate, but not seriously inadequate.

The structure is considered stable in its present configuration. However, because of the poor condition of the spillway, large discharges could possibly cause undermining

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of the spillway structure and erosion at the toe of the dam which could result in structural failure. Thus, the facility is considered unsafe, non-emergency. ↙

It is recommended that the owner:

- a. Develop a warning system to minimize the potential for loss of life and economic damage downstream of the facility in the event of a dam failure. The system should include provisions for around-the-clock surveillance during periods of unusually heavy precipitation and a communications plan with appropriate highway and railroad personnel.
- b. Provide the present outlet conduit with a blowoff valve or develop an alternate means of draining the reservoir.
- c. Have the spillway assessed by a registered professional engineer experienced in design of concrete and hydraulic structures and take remedial measures required to adequately restore its function.
- d. Have the deterioration and leakage observed on the downstream face of the dam assessed by a registered professional engineer experienced in the design of concrete structures and take remedial measures deemed necessary.
- e. Have the spillway system evaluated by a registered professional engineer experienced in hydrology and hydraulics and take remedial measures necessary to make the spillway hydraulically adequate.
- f. Develop formal manuals of maintenance and operations to ensure proper care of the facility.

GAI Consultants, Inc.

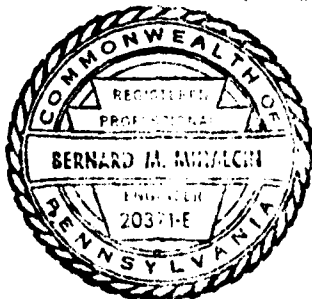
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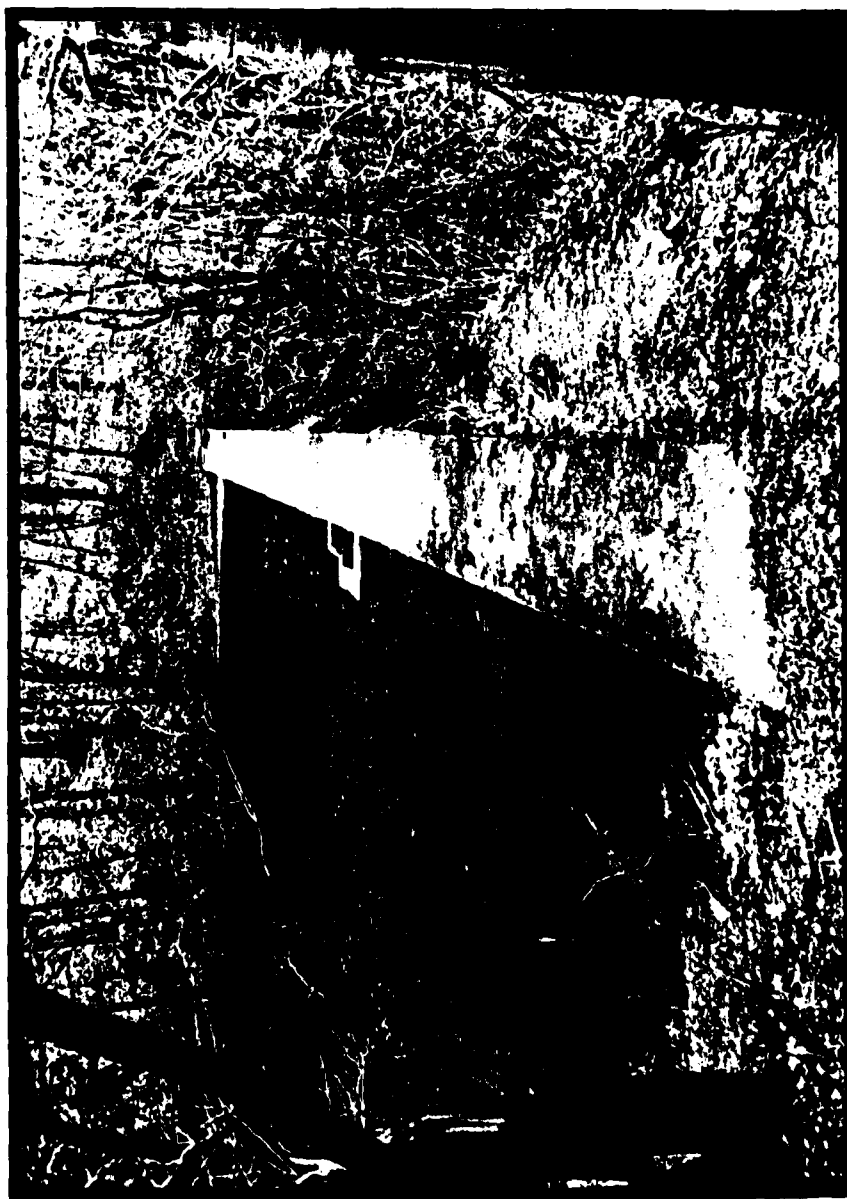
Bernard M. Mihalcin
Bernard M. Mihalcin, P.E.

James W. Pick
JAMES W. PICK
Colonel, Corps of Engineers
District Engineer
DLB:BMM/sam

Date 12 FEB 1980

DATE: 12 March 1980





OVERVIEW PHOTOGRAPH

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6
NATIONAL DAM INSPECTION PROGRAM

HAWSTONE DAM

(NDI# PA-00580, PENNDER# Number 44-7)

Number

Susquehanna River Basin

1.0 Authority. Tributary to Juniata River, Mifflin County, Pennsylvania. Phase I

The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

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Inspection
Report.

1.1 Purpose.

The purpose is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

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a. Dam and Appurtenances. Hawstone Dam is a concrete-gravity type structure approximately 34 feet high and about 157 feet long, including spillway. The spillway is an uncontrolled, rectangular, concrete chute channel located at the left abutment. The spillway crest is 17.4 feet long and has 3.1 feet of available freeboard. The facility is equipped with an 8-inch diameter cast iron pipe (CIP) supply main located near the right abutment. The supply line provides untreated domestic water to the nearby community of Hawstone, Pennsylvania. No means for draining the reservoir is presently available.

b. Location. Hawstone Dam is located in Granville Township, Mifflin County, Pennsylvania, 1 mile west of Hawstone, Pennsylvania on an unnamed tributary to the Juniata River. The City of Lewistown, Pennsylvania is located 5 miles west of the facility along Pennsylvania Route 333. The dam, reservoir, and watershed are located on the Lewis-town, Pennsylvania U.S.G.S. 7.5 minute topographic quadrangle (see Figure 1, Appendix E). The coordinates of the dam are N40° 34.9' and W77° 31.8'.

c. Size Classification. Small (34 feet high, 6.5 acre-feet storage at top of dam).

d. Hazard Classification. Significant (see Section 3.1.e).

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e. Ownership. John Hostetter
R.D. 8
Gettysburg, Pennsylvania 15325

f. Purpose. Water supply.

g. Historical Data. Hawstone Dam was designed and constructed in 1920 by the Berkebile Brothers of Johnstown, Pennsylvania for the Haws Refractories Company. The purpose of the facility was to supply domestic and industrial water to the village of Hawstone, Pennsylvania, and the owner's nearby silica brick plant.

PennDER files contains information pertaining to the facility between 1920 and 1961. Correspondence and memorandum indicate the facility was inspected frequently by the state and was repaired, for the most part, in accordance with the various recommendations of state inspectors. The last formal inspection took place in 1961. Deficiencies noted at that time included: a) spalling of the downstream dam face, b) a deteriorated concrete spillway channel and, c) a spillway approach partially obstructed by trees and brush. The above deficiencies still exist today and apparently were never corrected.

There are no records available from PennDER after 1961. Discussions with local residents revealed that the Haws Refractories Company shutdown its Hawstone operations in September 1968 and the plant was subsequently razed. Ownership of the dam has since been transferred to John Hostetter of Gettysburg, Pennsylvania. Mr. Hostetter reportedly permits free use of the facility's water supply to the community; however, he provides no maintenance. Costs of maintaining the water supply are borne, when necessary, by the citizens of Hawstone.

1.3 Pertinent Data.

a. Drainage Area (square miles). 0.22

b. Discharge at Dam Site.

Discharge Capacity of the Outlet Conduit - Discharge curves are not available.

Discharge Capacity of Spillway at Maximum Pool $\approx$ 290 cfs (see Appendix D, Sheet 8).

c. Elevation (feet above mean sea level). The following elevations were obtained through field measurements based on the elevation of normal pool at 592 feet (see Appendix D, Sheet 2, Note 2).

Top of Dam	595.1
Maximum Design Pool	Not known
Maximum Pool of Record	Not known
Normal Pool	592
Spillway Crest	592
Upstream Inlet Invert	565
Downstream Inlet Invert	Not applicable
Streambed at Dam Centerline	560
Maximum Tailwater	Not known
d. <u>Reservoir Length (feet).</u>	
Top of Dam	270
Normal Pool	250
e. <u>Storage (acre-feet).</u>	
Top of Dam	6.5
Normal Pool	5.2
Design Surcharge	Not known
f. <u>Reservoir Surface (acres).</u>	
Top of Dam	0.42
Normal Pool	0.37
Maximum Design Pool	Not known
g. <u>Dam.</u>	
Type	Concrete-gravity.
Length	157 feet (including spillway).
Height	34 feet (field measured; crest to downstream toe).
Top Width	6 feet.
Upstream Slope	Vertical (upper 15 feet). 0.8H:10V (toe to 15 feet below crest).
Downstream Slope	Vertical (upper 9 feet). 6:25 H:10V (toe to 9 feet below crest).
Concrete Type	1:3:6 mix embedded with 20 percent one-man stones.

Monolith Joints	Four key joints divide dam into 5 monoliths. Joints are spaced at 22, 51, 71, and 101 feet to the right of the spillway.
Grout Curtain	None indicated.
Cutoff	Foundation keyed into hard slate. Left abutment consists of 6-foot thick cutoff wall which extends to rock under the spillway slab.
h. <u>Diversion Canal and Regulating Tunnels.</u>	None.
i. <u>Spillway.</u>	
Type	Uncontrolled, rectangular, concrete chute channel with a broad crest.
Crest Elevation	592 feet.
Crest Length	17.4 feet.
j. <u>Outlet Conduit.</u>	
Type	8-inch diameter CIP supply line.
Length	1 mile (approximate distance to Hawstone).
Closure and Regulating Facilities	None. Control was previously provided via valve reportedly located about 80 feet downstream of the dam. Valve was removed in October 1979 and replaced with standard pipe section.
Access	None.

SECTION 2 ENGINEERING DATA

2.1 Design.

a. Design Data Availability and Sources. PennDER files contain design drawings and specifications along with a brief report entitled, "Data for Design of Hawstone Dam" by Berkebile Brothers, Engineers and Contractors, Johnstown, Pennsylvania (undated). The report considers conditions for the design of the dam cross-section including stability. Additionally, a state permit application report dated August 21, 1918 discusses design features of the facility in detail.

b. Design Features.

1. Dam. The dam is a gravity-type structure constructed of 1:3:6 mix concrete embedded with 20 percent one-man stone. The structure has a 6-foot top width. The downstream face is battered at 7.5 inches in 12 inches (6.25H:10V) to an elevation 9 feet below the crest, the upper 9 feet being vertical. The upstream face is battered at 1-inch in 12 inches (0.8H:10V) to an elevation 15 feet below the crest, the upper 15 feet being vertical (see Figure 4). A 6-foot thick cutoff wall extends from the gravity section into the left abutment under the spillway. The cutoff apparently is founded on rock but terminates in soil along the extreme left end.

Figure 3 shows the dam carried to a slate foundation across its length. Reportedly, the rock foundation is excavated to a depth of 4 to 5 feet with the bottom of the trench being stepped to offer greater sliding resistance. Additionally, several feet of earth backfill was apparently placed at the downstream toe.

2. Appurtenant Structures.

a) Spillway. The spillway is an uncontrolled, concrete, rectangular chute channel located at the left abutment. The crest is 17.4 feet long and is set 3.1 feet below the top of the wingwalls. The discharge channel follows the slope of the left abutment hillside, is 74 feet in length (see Figure 2), and is founded on soil.

b) Outlet Conduit. The outlet conduit consists of an 8-inch diameter cast iron supply pipe located about 40 feet from the right abutment. The inlet to the line is situated about 30 feet below the dam crest at the base of a concrete gate tower that abuts the upstream dam

face (see Figure 4). The original tower design provided for intakes at two different levels controlled via two 12-inch by 12-inch sluice gates located 16 and 30 feet below the crest. These gates, however, are no longer in place. Drawdown capability was originally provided by means of an 8-inch diameter gate valve located approximately 80 feet downstream of the dam. The valve was replaced in October 1979 with a standard pipe section. No alternate means of draining the reservoir is provided by the original design and, consequently, the facility has no current drawdown capability.

c. Specific Design Data and Criteria.

1. Hydrology and Hydraulics. No formal design reports or calculations are available. Correspondence contained in PennDER files indicates that the maximum design spillway capacity was reported to be 327 cfs based on a crest length of 18 feet and 3 feet of freeboard. This capacity was reported in 1918 to be "more than the expected runoff."

2. Dam. Design data and specifications are contained in PennDER files.

The following conditions were considered for the design of the cross-section.

I. Line of pressure for reservoir both full and empty must lie within the center third of the section.

II. The maximum pressure must not exceed 8 tons per square foot of masonry (note: dam was originally conceived as a masonry structure, but was eventually constructed of concrete).

III. The friction between horizontal sections and between the dam and its base must be sufficient to prevent sliding.

IV. Upward hydrostatic pressure on the base not considered.

V. Ice pressure not considered.

3. Appurtenant Structures. No specific design reports or calculations are available.

2.2 Construction Records.

Contract drawings, specifications, and several construction photographs are contained in PennDER files.

2.3 Operational Records.

No records of the present day-to-day operation of the facility are maintained.

2.4 Other Investigations.

Aside from periodic state inspections, no records of other formal investigations are available.

2.5 Evaluation.

The available data are considered adequate to make a reasonable Phase I assessment of the facility.

SECTION 3 VISUAL INSPECTION

3.1 Observations.

a. General. The general appearance of the facility indicates that the dam and its appurtenances are in poor condition.

b. Dam. The visual inspection indicates the dam is in poor condition. The upstream and downstream faces are extensively spalled and delaminated (see Photograph 3). Leakage emanates through a crack in the downstream face located approximately 60 feet from the right abutment and about 5 feet below the dam crest (see Photographs 2 and 4). The amount of seepage through the crack was slight and not measurable.

c. Appurtenant Structures.

1. Spillway. The present condition of the spillway is poor. The spillway channel and wingwalls are extensively cracked and spalled. Low flows through the spillway pass between large cracks and through holes in the upper portion of the channel eventually emerging beneath the right wingwall (see Photograph 7) and discharging across the downstream toe. On the day of the inspection several inches of water flowed over the spillway crest; however, the discharge end of the spillway channel remained dry (see Photographs 5 and 6). The spillway channel is partially obstructed by small trees and silt deposits that occupy the approach area (see Photograph 5).

2. Outlet Conduit. The outlet conduit is reportedly functional and serves to supply water to the residents of Hawstone. The original gate tower along the upstream dam face is deteriorated and stripped of its inlet control mechanisms (see Photograph 8). Drawdown control was previously provided by a valve located at a "T" section about 80 feet downstream of the dam. The valve was removed in October 1979 and replaced with a standard elbow pipe section such that currently, no means of draining the reservoir is available.

d. Reservoir Area. The reservoir formed by Hawstone Dam is small covering less than 1/2-acre at maximum pool. The general surrounding area is characterized by steep rocky slopes that are heavily forested (see Photograph 1). No signs of slope distress were observed.

e. Downstream Channel. Hawstone Dam is situated in a steep and narrow valley approximately 800 feet from the Juniata River (see Figure 1). Pennsylvania Route 333 crosses the stream immediately below the dam as do three active tracks of the Penn Central Railroad. No permanent or temporary structures occupy the area between the dam and the Juniata River. Since the dam is unattended and somewhat isolated, failure could occur and remain undetected for a short period. Undetected damage to either the highway or the railroad tracks could endanger those unsuspecting persons who utilize these routes. Consequently, it is possible that appreciable economic loss and loss of life could result from a dam failure. Thus, the hazard classification of the facility is considered significant.

3.2 Evaluation.

The overall appearance of the facility suggests it to be in poor condition. Spalled and delaminated concrete surfaces along with a severely cracked and partially obstructed spillway indicate an overall lack of adequate maintenance. In addition, no means for draining the reservoir is presently available.

SECTION 4 OPERATIONAL PROCEDURES

4.1 Normal Operating Procedure.

Hawstone Dam is essentially a self-regulating facility. Excess inflows are automatically discharged through the uncontrolled spillway. The owner permits free use of the facility's water supply to the residents of nearby Hawstone by means of an 8-inch diameter cast iron supply pipe. No means of drawing down the reservoir is provided. No formal operating manual is available.

4.2 Maintenance of Dam.

Visual observations indicate that maintenance of the dam is presently minimal to non-existent. Needed repairs to the supply line system, when required, are performed by the residents of Hawstone who finance the work through a community collection. No formal maintenance manual is available.

4.3 Maintenance of Operating Facilities.

See Section 4.2 above.

4.4 Warning System.

No formal warning system is in effect.

4.5 Evaluation.

Maintenance of the dam and appurtenances appears to be minimal to non-existent. No means of draining the reservoir is presently available. There are no formal operations or maintenance manuals available for the facility nor is there a formal warning system in effect that could be used to notify appropriate highway and railroad personnel should emergency conditions develop at the dam.

SECTION 5 HYDROLOGIC/HYDRAULIC EVALUATION

5.1 Design Data.

No formal design reports or calculations are available. Correspondence contained in PennDER files indicates that the maximum design spillway capacity was reported to be 327 cfs based on a crest length of 18 feet and 3 feet of freeboard. This capacity was reported in 1918 to be "more than the expected runoff."

5.2 Experience Data.

Daily records of reservoir levels and/or spillway discharge are not available.

5.3 Visual Observations

The visual inspection revealed the spillway to be in poor condition. Extensive cracking and spalling of the concrete wingwalls and channel raise questions as to the overall integrity of the spillway structure under unusually heavy flows.

5.4 Method of Analysis.

The facility has been analyzed in accordance with the procedures and guidelines established by the U.S. Army, Corps of Engineers, Baltimore District, for Phase I hydrologic and hydraulic evaluations. The analysis has been performed utilizing a modified version of the HEC-1 program developed by the U.S. Army, Corps of Engineers, Hydrologic Engineering Center, Davis, California. Analytical capabilities of the program are briefly outlined in the preface contained in Appendix D.

5.5 Summary of Analysis.

a. Spillway Design Flood (SDF). In accordance with procedures and guidelines contained in the National Guidelines for Safety Inspection of Dams for Phase I Investigations, the Spillway Design Flood (SDF) for Hawstone Dam ranges between the 100-year flood and the 1/2 PMF (Probable Maximum Flood). This classification is based on the relative size of the dam (small), and the potential hazard of

dam failure to downstream developments (significant). Due to the present potential for economic loss and possibly loss of life, the SDF for this facility is considered to be the 1/2 PMF.

b. Results of Analysis. Hawstone Dam was evaluated under near normal operating conditions. That is, the reservoir was initially at its normal pool or spillway elevation of 592 feet (MSL), with the spillway weir discharging freely. The outlet conduit was assumed to be non-functional. The spillway is a rectangular-shaped concrete chute channel with discharges controlled by a concrete broad-crested weir. All pertinent engineering calculations relative to the evaluation of this facility are provided in Appendix D.

Overtopping analysis (using the Modified HEC-1 Computer Program) indicated that the discharge/storage capacity of Hawstone Dam can accommodate only about 39 percent of the PMF prior to overtopping of the dam (Appendix D, Summary Input/ Output Sheets, Sheet C). The peak 1/2 PMF inflow of approximately 370 cfs was not attenuated by the discharge/storage capabilities of the dam and reservoir, as the resulting peak 1/2 PMF outflow was also about 370 CFS (Summary Input/ Output Sheets, Sheet C). Under the 1/2 PMF, the dam would be overtopped for approximately 1.5 hours, with a maximum depth of inundation equal to about 0.3 feet (elevation 595.4 feet) above the low top of dam at elevation 595.1 feet (Summary Input/Output Sheets, Sheet C).

5.6 Spillway Adequacy.

Although Hawstone Dam cannot accommodate its SDF (1/2 PMF), the possible downstream consequences of dam failure due to overtopping were not evaluated. In accordance with Corps directive ETL-1110-2-234, breaching analysis of the dam was not performed, since the downstream reach was classified not as "high hazard," but as "significant hazard." Since Hawstone Dam cannot accommodate a 1/2 PMF-size flood, its spillway is considered to be inadequate, but not seriously inadequate.

SECTION 6
EVALUATION OF STRUCTURAL INTEGRITY

6.1 Visual Observations.

a. Dam. The visual inspection revealed the dam to be in poor condition, the apparent result of years of neglect and lack of adequate preventive maintenance. Continued deterioration could eventually lead to failure of the dam.

b. Appurtenant Structures.

1. Spillway. Visual observations indicate the spillway is in poor condition. Extensive cracking and concrete deterioration raise doubts as to the ability of the structure to withstand increased stresses concurrent with high flows. Water passing through cracks in the channel serves to undermine the soil foundation and could eventually lead to the collapse of the structure.

2. Outlet Conduit. The outlet conduit is reportedly functional in its capacity as a supply line; however, no means for draining the reservoir is presently available.

6.2 Design and Construction Techniques.

Little design information is available except for data relative to the design of the maximum dam section. It is noted that the designers analyzed the stability of the dam (sliding and overturning) by assuming no hydrostatic uplift pressure along its base. Such an assumption is contrary to modern accepted practice; however, local geologic conditions may indeed uphold its validity.

Stability relative to sliding and overturning was analyzed as part of this evaluation (see Appendix D-1, Sheets 1 through 6). Unacceptable safety factors (sliding = 0.7, overturning = 1.2) were obtained under full hydrostatic uplift; whereas, acceptable safety factors (sliding = 1.2, overturning = 2.4) resulted when uplift pressures were ignored as in the original design calculations. Only further investigation can accurately determine the existing condition relative to hydrostatic uplift. Nevertheless, the stability of the dam is undoubtedly greatly enhanced by the reported existence of foundation keys and by the fact that the downstream toe is buttressed by about 10 feet of soil and possibly rock. Based on the fact that the dam has been

in service for some 60 years and has probably experienced high flows approaching maximum pool level, the facility is believed to be stable. However, should the dam ever be overtopped or should the deteriorated spillway fail, it is likely that this toe support could be eroded leading to the failure of structure.

6.3 Past Performance.

PennDER records indicate that during the years under the ownership of the refractory, maintenance was performed regularly on the facility. The refractory closed in September 1968 (records are incomplete) and, subsequently, the dam was sold. A comparison of photographs of the facility dated 1961 indicate its condition to have progressively worsened due to an apparent lack of adequate maintenance.

6.4 Seismic Stability.

The dam is located within Seismic Zone No. 1 and may be subject to minor earthquake induced dynamic forces. The facility is presently considered to be stable and it is believed that, if static conditions continue to be satisfied, the dam can withstand the expected dynamic forces. However, no calculations or investigations were performed to confirm this opinion.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS FOR REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety. The results of this evaluation indicate the facility is in poor condition.

The size classification of the facility is small and its hazard classification is considered to be significant. In accordance with the recommended guidelines, the range of the Spillway Design Flood (SDF) for the facility is the 100-year flood to the 1/2 PMF (Probable Maximum Flood). Due to the potential for loss of life from sudden failure of the dam, the SDF is considered to be the 1/2 PMF. Results of the hydrologic and hydraulic analysis indicate the facility will pass and/or store about 39 percent of the PMF prior to dam overtopping. Thus, based on criteria contained in the recommended guidelines, the spillway is considered inadequate, but not seriously inadequate.

For the most part, deficiencies noted by the inspection team can be attributed to a lack of adequate maintenance which has allowed advanced stages of deterioration. Spalled and delaminated concrete surfaces along both faces of the dam and extensive cracking of the spillway structure are considered major causes for concern.

Although the structure is considered stable presently, it is difficult to assess the adequacy of its original design without further study. It is believed that if the dam were to be overtopped or if the deteriorated spillway would fail, toe support could be lost due to erosion possibly resulting in failure of the structure.

b. Adequacy of Information. The available data are considered sufficient to make a reasonable Phase I assessment of the facility.

c. Urgency. The following recommendations should be implemented immediately.

d. Necessity for Additional Investigations. Additional investigations to assess the structural and hydraulic adequacy of the spillway as well as leakage through the downstream dam face are considered necessary and are recommended below.

7.2 Recommendations/Remedial Measures.

It is recommended that the owner immediately:

- a. Develop a warning system to minimize the potential for loss of life and economic damage downstream of the facility in the event of a dam failure. The system should include provisions for around-the-clock surveillance during periods of unusually heavy precipitation and a communications plan with appropriate highway and railroad personnel.
- b. Provide the present outlet conduit with a blowoff valve or develop an alternate means of draining the reservoir.
- c. Have the spillway assessed by a registered professional engineer experienced in the design of concrete and hydraulic structures and take remedial measures required to adequately restore its function.
- d. Have the deterioration and leakage observed on the downstream face of the dam assessed by a registered professional engineer experienced in the design of concrete structures and take remedial measures deemed necessary.
- e. Have the spillway system evaluated by a registered professional engineer experienced in hydrology and hydraulics and take remedial measures necessary to make the spillway hydraulically adequate.
- f. Develop formal manuals of maintenance and operations to ensure proper care of the facility.

APPENDIX A
VISUAL INSPECTION CHECKLIST AND FIELD SKETCHES

CHECK LIST VISUAL INSPECTION PHASE 1

NAME OF DAM Hawstone Dam STATE Pennsylvania COUNTY Mifflin

NDI # PA -- 00580 PENNDR # 44-7

TYPE OF DAM Concrete-Gravity SIZE Small HAZARD CATEGORY Significant

DATE(S) INSPECTION 26 November 1979 WEATHER Rain TEMPERATURE 50° @ 1:00 pm

POOL ELEVATION AT TIME OF INSPECTION 592.3 feet M.S.L.

TAILWATER AT TIME OF INSPECTION N/A M.S.L.

INSPECTION PERSONNEL	OWNER REPRESENTATIVES	OTHERS
<u>B. M. Mihalcin</u>	<u>None Present</u>	
<u>D. J. Spaeder</u>		
<u>D. L. Bonk</u>		

RECORDED BY D. L. Bonk

CONCRETE DAM

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDI# PA - 00580
CONCRETE SURFACES	Crest in good condition. Upstream and downstream faces exhibit extensive concrete deterioration characterized by spalling, cracking, and delamination.	
HORIZONTAL JOINTS	None observed due to extensive deterioration of the downstream face.	
MONOLITHIC JOINTS	Joints separating individual concrete pours are visible across crest at 22, 51, 71 and 101 feet to the right of the spillway.	
EFFLORESCENCE	Prevalent around cracks and joints along both the upstream and downstream faces.	
JUNCTION OF DAM AND ABUTMENT	Good condition.	

CONCRETE DAM

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDIN PA - 00580
VERTICAL AND HORIZONTAL ALIGNMENT	Good condition.	
ANY NOTICEABLE SEEPAGE	Slight leakage through vertical portion of downstream face to the left of the outlet conduit gate tower.	
STAFF GAGE AND RECORDER	None observed.	
DRAINS	None observed.	

OUTLET WORKS

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDI# PA. 00580
INTAKE STRUCTURE	Concrete gate tower along upstream embankment face in poor condition. Original slide gate control mechanisms have been removed, thus, flow is no longer controlled at the inlet. Tower is flooded and its interior presently inaccessible.	
OUTLET CONDUIT (CRACKING AND SPALLING OF CON- CRETE SURFACES)	8-inch diameter cast iron pipe (CIP).	
OUTLET STRUCTURE	None.	
OUTLET CHANNEL	Flow from blowoff was previously discharged into the wooded, V-shaped valley immediately below Hawstone Dam (see below).	
GATE(S) AND OPERA- TIONAL EQUIPMENT	8-inch diameter gate valve formerly located on supply line approximately 80 feet downstream of dam was removed in the fall of 1979 and replace with a standard section of pipe. Presently dam cannot be drained without cutting the supply line.	

EMERGENCY SPILLWAY

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDI# PA - 00580
TYPE AND CONDITION	Uncontrolled, concrete, rectangular, chute channel spillway located at left abutment. Poor condition.	
APPROACH CHANNEL	Small unlined approach area partially obstructed by debris and vegetation.	
SPILLWAY CHANNEL AND SIDEWALLS	Concrete channel and sidewalls are extensively cracked and deteriorated. Small discharges over spillway weir pass through cracks in the channel floor adjacent the right wingwall. Water flows underneath the structure and eventually across the downstream embankment toe.	
STILLING BASIN PLUNGE POOL	N/A	
DISCHARGE CHANNEL	Spillway flow is discharged into the wooded V-shaped valley immediately below Hawstone Dam prior to entering the Juniata River.	
BRIDGE AND PIERS EMERGENCY GATES	None.	

SERVICE SPILLWAY

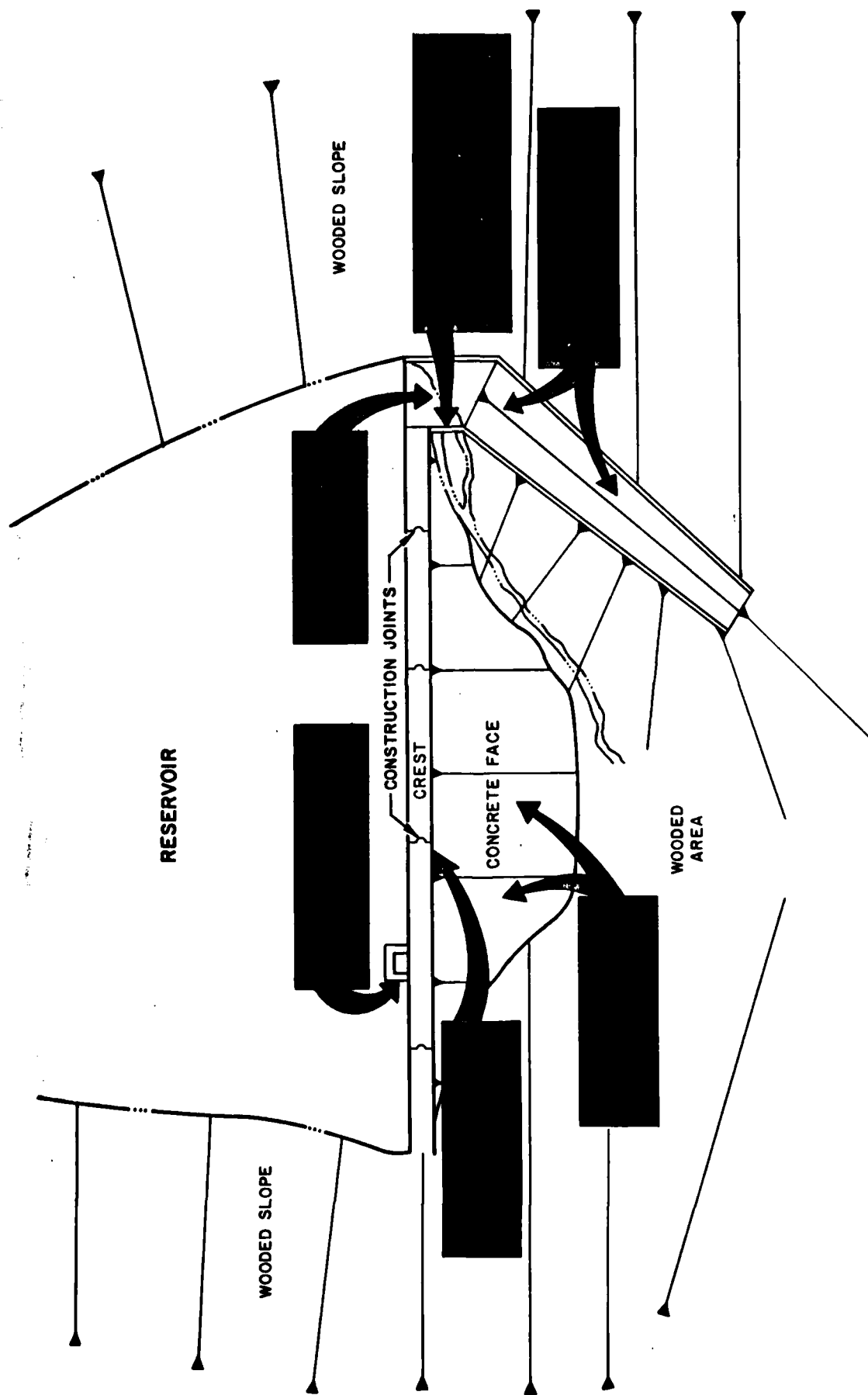
ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDI# PA - 00580
TYPE AND CONDITION	N/A	
APPROACH CHANNEL	N/A	
OUTLET STRUCTURE	N/A	
DISCHARGE CHANNEL	N/A	

INSTRUMENTATION

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDI# PA - 00580
MONUMENTATION SURVEYS	None observed.	
OBSERVATION WELLS	None observed.	
WEIRS	Small concrete, V-notch weir located several hundred feet upstream of dam along incoming stream.	
PIEZOMETERS	None observed.	
OTHERS		

RESERVOIR AREA AND DOWNSTREAM CHANNEL

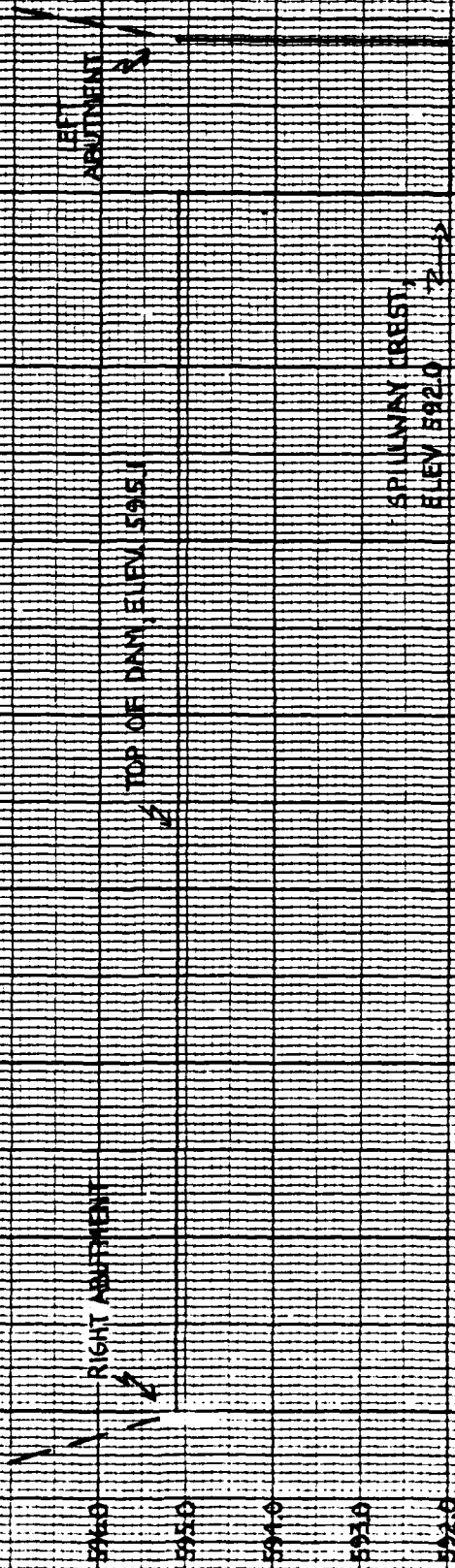
ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDI# PA · 00580
SLOPES: RESERVOIR	The general surrounding area is characterized by steep rocky slopes that are heavily forested. No signs of slope distress observed.	
SEDIMENTATION	None observed.	
DOWNSTREAM CHAN- NEL (OBSTRUCTIONS, DEBRIS, ETC.)	The dam is situated about 800 feet off the Juniata River. Normal stream flow passes through small culverts beneath PA Route 333 and three active tracks of the Penn Central railroad prior to reaching the Juniata River.	
SLOPES: CHANNEL VALLEY	Steep, narrow, wooded valley.	
APPROXIMATE NUMBER OF HOMES AND POPULATION	No permanent or temporary structures occupy the area between the dam and the Juniata River approximately 800 feet downstream. PA Route 333 crosses the stream immediately below the dam as do three active tracks of the Penn Central Railroad.	



HAWSTONE DAM
GENERAL PLAN - FIELD INSPECTION NOTES

HAWSTONE DAM

PROFILE OF DAM CREST
FROM FIELD SURVEY



SCALE:

VERTICAL: 1" = 2 FT

HORIZONTAL: 1" = 20 FT

APPENDIX B
ENGINEERING DATA CHECKLIST

**CHECK LIST
ENGINEERING DATA
PHASE I**

NAME OF DAM Hawstone Dam

ITEM	REMARKS	NO# PA - 00580
PERSONS INTERVIEWED AND TITLE	John Hostetter (owner: interviewed via telephone). Floyd Ciccalini (unofficial spokesman for community of Hawstone, Pennsylvania: interviewed via telephone).	
REGIONAL VICINITY MAP	See Figure 1, Appendix E.	
CONSTRUCTION HISTORY	Designed and constructed by Berkebile Brothers of Johnstown, Pennsylvania for the Haws Refractories Company in 1920 (see Section 1.2.g).	
AVAILABLE DRAWINGS	Drawings dated 1918 by Berkebile Brothers are contained in PennDER files (see Figures 2, 3, 4, and 5, Appendix E).	
TYPICAL DAM SECTIONS	See Figures 2, 3, and 4, Appendix E.	
OUTLETS: PLAN DETAILS DISCHARGE RATINGS	See Figure 2, Appendix E. See Figure 4, Appendix E. Not available.	

**CHECK LIST
ENGINEERING DATA
PHASE I
(CONTINUED)**

ITEM	REMARKS	NDI# PA. 00580
SPILLWAY: PLAN SECTION DETAILS	See Figure 2, Appendix E. See Figure 3 and 4, Appendix E. None available.	
OPERATING EQUIP- MENT PLANS AND DETAILS	See Figure 4, Appendix E.	
DESIGN REPORTS	None available.	
GEOLOGY REPORTS	None available.	
DESIGN COMPUTATIONS: HYDROLOGY AND HYDRAULICS STABILITY ANALYSES SEEPAGE ANALYSES	Data utilized for the design of the maximum cross-section is contained in a brief report entitled "Data for Design of Hawstone Dam," by Berkebile Brothers (undated).	
MATERIAL INVESTIGATIONS: BORING RECORDS LABORATORY TESTING FIELD TESTING	See Figure 3, Appendix E.	

**CHECK LIST
ENGINEERING DATA
PHASE I
(CONTINUED)**

ITEM	REMARKS	NDI# PA - 00580
BORROW SOURCES	Not applicable.	
POST CONSTRUCTION DAM SURVEYS	None.	
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Records of state inspections are contained in PennDER files. State permit application report dated August 21, 1918 discusses various design aspects in detail.	
HIGH POOL RECORDS	None available. Dam reportedly has never been overtopped.	
MONITORING SYSTEMS	None.	
MODIFICATIONS	Gate valve on supply line 80 feet downstream of dam was replaced in October 1979 with a standard pipe section, thereby eliminating the only available means of draining the reservoir.	

**CHECK LIST
ENGINEERING DATA
PHASE I
(CONTINUED)**

ITEM	REMARKS	NDI# PA - 00580
PRIOR ACCIDENTS OR FAILURES	None recorded.	
MAINTENANCE: RECORDS MANUAL	None.	
OPERATION: RECORDS MANUAL	None.	
OPERATIONAL PROCEDURES	Totally self-regulating.	
WARNING SYSTEM AND/OR COMMUNICATION FACILITIES	None.	
MISCELLANEOUS		

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**CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA**

NDI ID # 00580
PENNDER ID # 44-7

SIZE OF DRAINAGE AREA: 0.22 square miles.
ELEVATION TOP NORMAL POOL: 592 STORAGE CAPACITY: 5.2 acre-feet
ELEVATION TOP FLOOD CONTROL POOL: - STORAGE CAPACITY: -
ELEVATION MAXIMUM DESIGN POOL: - STORAGE CAPACITY: -
ELEVATION TOP DAM: 595.1 STORAGE CAPACITY: 6.5 acre-feet

SPILLWAY DATA

CREST ELEVATION: 592 feet.
TYPE: Uncontrolled, concrete, rectangular chute channel.
CREST LENGTH: 17.4 feet.
CHANNEL LENGTH: 74 feet.
SPILLOVER LOCATION: Left abutment.
NUMBER AND TYPE OF GATES: None.

OUTLET WORKS

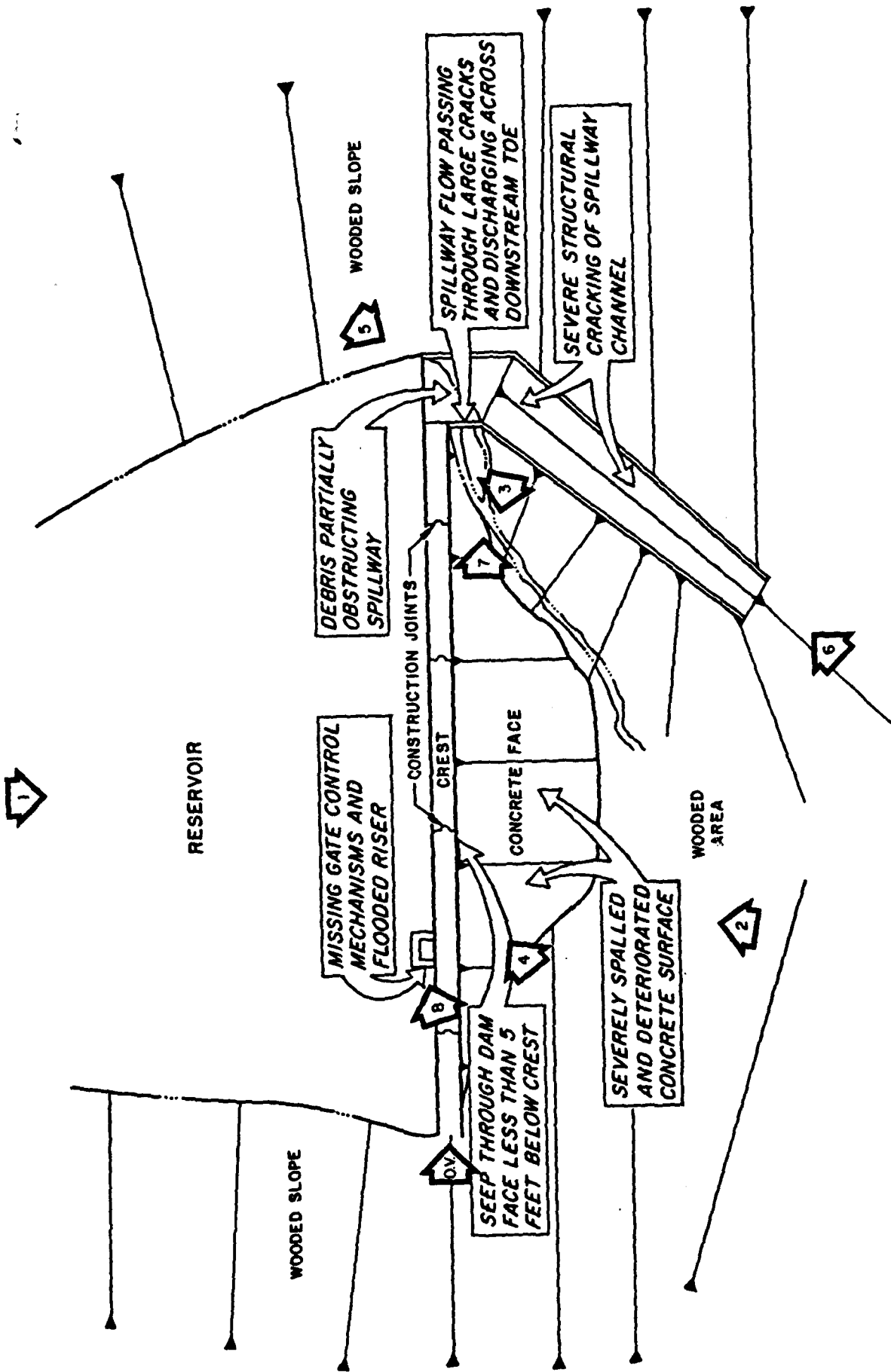
TYPE: 8-inch diameter CIP supply line.
LOCATION: Near right abutment.
ENTRANCE INVERTS: 565 feet.
EXIT INVERTS: Not available.
EMERGENCY DRAWDOWN FACILITIES: None.

HYDROMETEOROLOGICAL GAGES

TYPE: None.
LOCATION: -
RECORDS: -

MAXIMUM NON-DAMAGING DISCHARGE: Not known.

APPENDIX C
PHOTOGRAPHS



HAWSTONE DAM
PHOTOGRAPH KEY MAP

PHOTOGRAPH 1 View of the reservoir and upstream face of Hawstone Dam.

PHOTOGRAPH 2 View of the downstream face of Hawstone Dam.

PHOTOGRAPH 3 Close-up view of the deteriorated concrete condition along the downstream dam face as seen from the spillway wingwall.

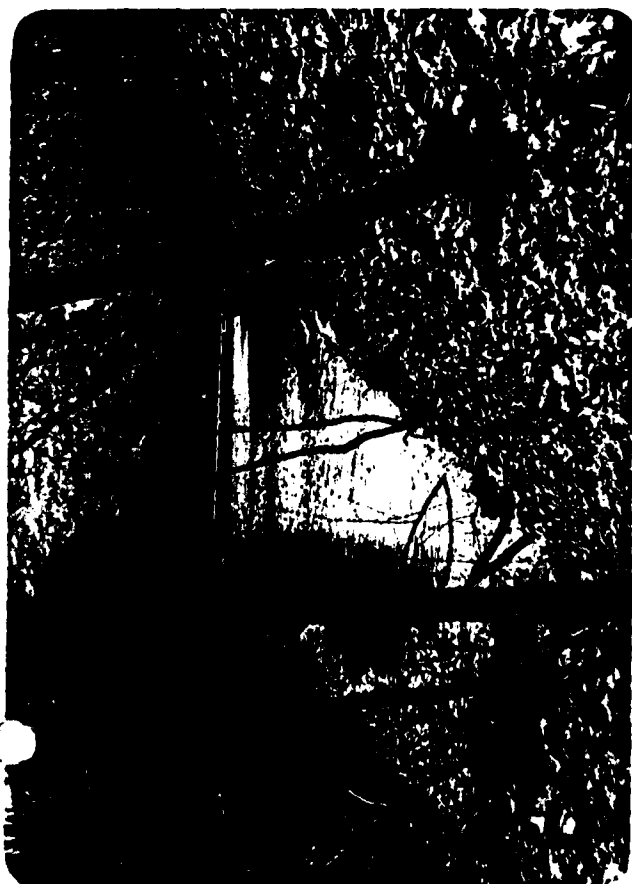
PHOTOGRAPH 4 Close-up view of an area of leakage (black area in upper center portion of view) through the downstream dam face.



2



4



1



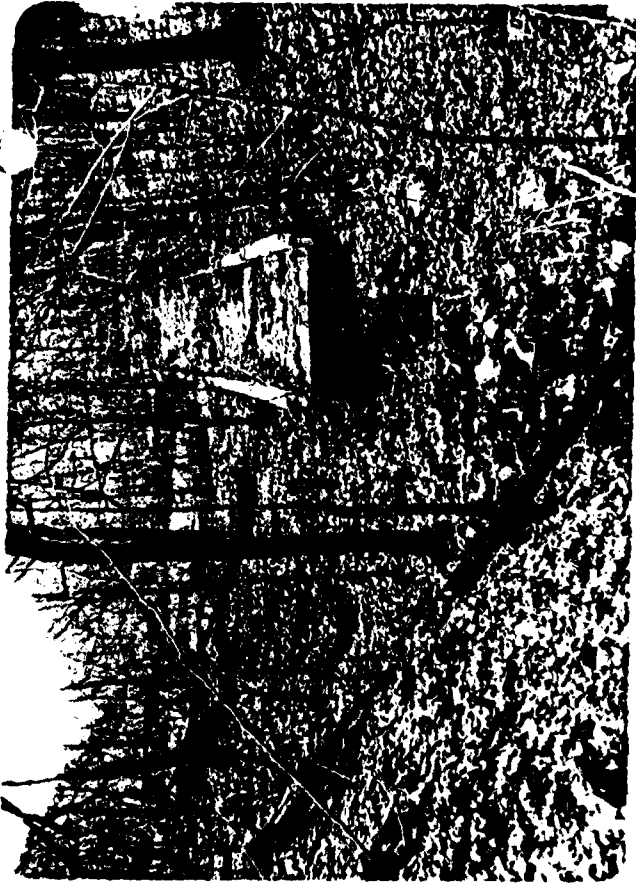
3

PHOTOGRAPH 5 View, looking downstream, of the entrance to the spillway as seen from the left abutment hillside.

PHOTOGRAPH 6 View, looking upstream, of the spillway discharge channel.

PHOTOGRAPH 7 View of spillway flow discharging beneath the spillway right wingwall.

PHOTOGRAPH 8 View of the deteriorated and dismantled gate tower that abuts the upstream dam face near the right abutment.



6



8



5



7

APPENDIX D

HYDROLOGY AND HYDRAULICS ANALYSES

PREFACE

The modified HEC-1 program is capable of performing two basic types of hydrologic analyses: 1) the evaluation of the overtopping potential of the dam; and 2) the estimation of the downstream hydrologic-hydraulic consequences resulting from assumed structural failures of the dam. Briefly, the computational procedures typically used in the dam overtopping analysis are as follows:

- a. Development of an inflow hydrograph(s) to the reservoir.
- b. Routing of the inflow hydrograph(s) through the reservoir to determine if the event(s) analyzed would overtop the dam.
- c. Routing of the outflow hydrograph(s) from the reservoir to desired downstream locations. The results provide the peak discharge(s), time(s) of the peak discharge(s), and the maximum stage(s) of each routed hydrograph at the downstream end of each reach.

The evaluation of the hydrologic-hydraulic consequences resulting from an assumed structural failure (breach) of the dam is typically performed as shown below.

- a. Development of an inflow hydrograph(s) to the reservoir.
- b. Routing of the inflow hydrograph(s) through the reservoir.
- c. Development of a failure hydrograph(s) based on specified breach criteria and normal reservoir outflow.
- d. Routing of the failure hydrograph(s) to desired downstream locations. The results provide estimates of the peak discharge(s), time(s) to peak and maximum water surface elevations of failure hydrographs for each location.

HYDROLOGY AND HYDRAULIC ANALYSIS DATA BASE

NAME OF DAM: HAWSTONE DAM

PROBABLE MAXIMUM PRECIPITATION (PMP) = 22.2 INCHES/24 HOURS ⁽¹⁾

STATION	1	2	3
STATION DESCRIPTION	HAWSTONE DAM		
DRAINAGE AREA (SQUARE MILES)	0.22		
CUMULATIVE DRAINAGE AREA (SQUARE MILES)			
ADJUSTMENT OF PMF FOR DRAINAGE AREA LOCATION (%) ⁽¹⁾			
6 HOURS	121		
12 HOURS	131		
24 HOURS	140		
48 HOURS	147		
72 HOURS	149		
SNYDER HYDROGRAPH PARAMETERS			
ZONE (2)	21		
C _p (3)	0.55		
C _t (3)	1.50		
L (MILES) (4)	0.9		
L _{ca} (MILES) (4)	0.4		
t _p = C _t (L · L _{ca}) ^{0.3} (HOURS)	1.10		
SPILLWAY DATA			
CREST LENGTH (FEET)	17.4		
FREEBOARD (FEET)	3.1		

(1) HYDROMETEOROLOGICAL REPORT 40, U.S. WEATHER BUREAU, 1965.

(2) HYDROLOGIC ZONE DEFINED BY CORPS OF ENGINEERS, BALTIMORE DISTRICT, FOR DETERMINATION OF SNYDER COEFFICIENTS (C_p AND C_t).

(3) SNYDER COEFFICIENTS

(4) L = LENGTH OF LONGEST WATERCOURSE FROM DAM TO BASIN DIVIDE.

L_{ca} = LENGTH OF LONGEST WATERCOURSE FROM DAM TO POINT OPPOSITE BASIN CENTROID.

PROJECT DAM SAFETY INSPECTION
HOWSTONE DAM
 BY JTS DATE 1-2-82 PROJ. NO. 79-202-580
 CHKD. BY DLB DATE 1-8-80 SHEET NO. 1 OF 11



DAM STATISTICS

- HEIGHT OF DAM = 34 FT (FIELD MEASUREMENT)
- NORMAL POOL STORAGE CAPACITY = 1.685 X 10⁶ GALLONS
 = 5.17 ACRE-FT (NOTE 1)
 = 5.2 ACRE-FT
- MAXIMUM POOL STORAGE CAPACITY = 6.7 ACRE-FT = 6.5 ACRE-FT (SHEET 5,
 (@ LOW TOP OF DAM)
- DRAINAGE AREA = 0.22 SQUARE MILES { PLANNED BY USGS 7.5
 MINUTE TOPOG. MAP
 1960-1961 }
- ELEVATION OF TOP OF DAM (FIELD) = 595.1
- NORMAL POOL ELEVATION = 592.0 (FIGURE 3, SEE NOTE 2)
- UPSTREAM INLET INVERT ELEVATION = 565.0 (FIGURE 4, SEE NOTE 2)
- DOWNSTREAM OUTLET INVERT - NOT KNOWN
- STREAMBED @ DAM CENTERLINE 560.0 (FIGURE 2, SEE NOTE 2)

NOTE 1: OBTAINED FROM "REPORT UPON THE ANALYSIS OF MAJOR
 RESERVOIRS CO., HOWSTONE DAM, AUGUST, 1919; PART IN TOWNE'S
 FILES.

PROJECT DAM SAFETY INSPECTION
HAWKSTONE DAM
 BY DJS DATE 1-2-80 PROJ. NO. 79-303-530
 CHKD. BY DLO DATE 1-8-80 SHEET NO. 2 OF 11



NOTE 2: DESIGN DRAWINGS ARE BASED ON A NORMAL POOL ELEVATION OF 313.0 FEET. HOWEVER, THE USGS TOPO QUAD FOR LEWISTOWN, IN, INDICATES THAT NORMAL POOL ELEVATION IS SOMEWHERE BETWEEN 580.0 AND 600.0. THE RESERVOIR AREA AT ELEVATION 320.0, AS PLANIMETERED ON FIGURE 5, IS APPROXIMATELY 0.53 ACRES, WHICH IS ALSO THE VALUE OBTAINED AT ELEVATION 600.0 ON THE USGS TOPO MAP. THUS, IT WILL BE ASSUMED THAT ELEVATION 320.0 ON THE DESIGN DRAWINGS CORRESPONDS TO ELEVATION 600.0 ON THE USGS TOPO. THEREFORE, A VALUE OF 380.0 HAS BEEN ADDED TO ALL THE RELATED ELEVATIONS ON THE DESIGN DRAWINGS. FOR INSTANCE, NORMAL POOL ELEVATION, REVISED AS 313.0 FEET, WILL BE ASSUMED TO BE 313.0 + 380.0, OR 593.0. (NOTE: THE ELEVATIONS USED IN THIS ANALYSIS ARE CONSIDERED ESTIMATES AND ARE NOT NECESSARILY ACCURATE).

DAM CLASSIFICATION

DAM SIZE : SMALL (REF 1, TABLE 1)
 HAZARD CLASSIFICATION : SIGNIFICANT (FIELD OBSERVATION)
 REQUIRED SDF : 100-YEAR TO $\frac{1}{2}$ PMF (REF 1, TABLE 3)

HYDROGRAPH PARAMETERS

- LENGTH OF LONGEST WATERCOURSE : 2.9 MILES (MEASURED ON USGS TOPO QUAD 15N 15E)
- LENGTH OF LONGEST WATERCOURSE FROM DAM TO A POINT OPPOSITE DAM CENTROID : 2.4 MILES

PROJECT DAM SAFETY INSPECTION
HAWSTOWN DAM
 BY DJS DATE 1-2-80 PROJ. NO. 79-200-520
 CHKD. BY DLB DATE 1-8-80 SHEET NO. 3 OF 11



$$C_e = \underline{1.50}$$

$$C_p = \underline{0.55}$$

(SUPPLIED BY COE, ZONE 21,
JUSQUISHANNA RIVER BASIN.)

SNYDER'S STANDARD LAG: $t_p = C_e (L - L_{ca})^{0.3}$
 $= (1.50) (0.9 \times 0.4)^{0.3}$
 $= \underline{1.10 \text{ HOURS}}$

(NOTE: HYDROGRAPH VARIABLES USED HERE ARE DEFINED IN REFERENCE 3,
IN SECTIONS ENTITLED "UNDER SYNTHETIC UNIT HYDROLOGY.")

RESERVOIR CAPACITY TABLE

RESERVOIR SURFACE AREAS:

RESERVOIR ELEVATION (FT)	SURFACE AREA * (ACRES)
561.0	0
565.0	0.04
570.0	0.08
575.0	0.10
580.0	0.14
585.0	0.25
590.0	0.33
595.0	0.37
598.0	0.42
600.0	0.50
601.0	0.55

* SURFACE AREA AT A GIVEN ELEVATION WAS DETERMINED BY PLACING 5' SPACING CONTOUR LINES ON
(SEE NOTE 1); AREA AT ELEVATION 601.0 WAS DETERMINED BY USING THIS ELEVATION AS A BASE.

PROJECT Dam Safety Inspection
MAJESTIC DAM
 BY DJS DATE 1-3-80 PROJ. NO. 77-100-10
 CHKD. BY DLB DATE 1-8-80 SHEET NO. 4 OF 11



IT IS ASSUMED THAT THE MODIFIED PRISMATOIDAL RELATIONSHIP ADEQUATELY MODELS THE RESERVOIR SURFACE AREA + STORAGE RELATIONSHIP. SINCE THE CAPACITY AT NORMAL POOL IS KNOWN, THE CALCULATED VOLUMES CAN BE ADJUSTED ACCORDINGLY.

$$\Delta V_{1-2} = \frac{h}{3} (A_1 + A_2 + \sqrt{A_1 \cdot A_2}) \quad (CE = 7, p. 15)$$

WHERE ΔV_{1-2} = INCREMENTAL VOLUME BETWEEN ELEVATIONS 1 & 2, IN FEET,
 h = ELEVATION 1 - ELEVATION 2, IN FEET,
 A_1 = SURFACE AREA AT ELEVATION 1, IN ACRES,
 A_2 = SURFACE AREA AT ELEVATION 2, IN ACRES.

ALSO, ASSUME THAT THE SURFACE AREA VARIES LINEARLY BETWEEN ELEVATIONS 600.0 AND 620.3.

$$\begin{aligned} A_c &= A_{600} + \left(\frac{\Delta SA}{\Delta H} \times H \right) \quad \text{ACRES} \\ &= 0.53 + \left(\frac{1.09 - 0.53}{620.0 - 600.0} \times H \right) \\ &= 0.53 + (0.0045 \times H) \end{aligned}$$

WHERE H = ELEV c - 600.0 FT

IT IS ALSO ASSUMED THAT SURFACE AREA VARIES LINEARLY BETWEEN ELEVATIONS 590.0 AND 595.0, AND BETWEEN 595.0 AND 600.3.

$$\begin{aligned} \text{BETWEEN 590.0 AND 595.0: } A_c &= A_{590} + \left(\frac{2.42 - 2.77}{595 - 590} \times H \right) \\ &= 2.57 + (2.0167 \times H) \end{aligned}$$

$$\begin{aligned} \text{BETWEEN 595.0 AND 600.3: } A_c &= A_{595} + \left(\frac{0.53 - 2.42}{600 - 595} \times H \right) \\ &= 0.42 + (2.396 \times H) \end{aligned}$$

PROJECT DAM SAFETY INSPECTION
HAWKSTONE DAM
 BY DJS DATE 1-3-80 PROJ. NO. 72-202-553
 CHKD. BY DLB DATE 1-8-80 SHEET NO. 5 OF 11

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ELEVATION - STORAGE TABLE :

RESERVOIR ELEVATION (FT)	AL (ACRES)	ΔV_{1-2} (AC-FT)	INITIAL CALCULATED TOTAL VOLUME (AC-FT)	FINAL CALCULATED VOLUME (AC-FT) *
561.0 **	0	-	0	0
565.0	0.04	0.05	0.05	0.05
570.0	0.06	0.09	0.34	0.36
575.0	0.12	0.50	0.84	0.84
580.0	0.19	0.77	1.61	1.71
585.0	0.25	1.10	2.71	2.88
590.0	0.33	1.45	4.16	4.43
(NORMAL POOL) 592.0	0.37	0.70	4.86	5.17
593.0	0.39	0.38	5.24	5.58
594.0	0.40	0.39	5.63	5.99
595.0	0.42	0.41	6.04	6.43
(TOP OF DAM) 595.1	0.42	0.04	6.08	6.47
596.0	0.44	0.39	6.47	6.88
598.0	0.49	0.93	7.40	7.87
600.0	0.53	1.02	8.42	8.96
603.0	0.58	1.11	9.53	10.14
605.0	0.65	1.84	11.37	13.10

* FINAL CALCULATED VOLUME = (INITIAL CALCULATED VOLUME) X (CORRECTION FACTOR),
 WHERE CORRECTION FACTOR = $\left(\frac{\text{KNOWN VOLUME AT NORMAL POOL}}{\text{INITIAL CALCULATED VOL. AT NORMAL POOL}} \right)$
 $= \frac{5.7}{4.96} = 1.064$

** FROM FIGURE 5.

PROJECT DAM SAFETY INSPECTION
HEWITSON DAM
 BY JTS DATE 1-4-80 PROJ. NO. 78-010-583
 CHKD. BY DLB DATE 1-8-80 SHEET NO. 6 OF 11



PMP CALCULATIONS

- FROM REFERENCE 7, FIGURE 8, OBTAIN PMP VALUE FOR A BASIN OF DRAINAGE AREA 200 SQUARE MILES, AND FOR A DURATION OF 24 HOURS:

PRECIP = 22.2 INCHES

- FROM REF 7, FIG 1, THE SEDIMENTATION ADJUSTMENT FACTOR = 103%

- AREA CORRECTION FACTOR (REF 9):

DURATION (HRS):	6	12	24	48	72
FACTOR (%) :	117.5	137.0	136.3	142.5	145.3

- TOTAL CORRECTION FACTOR (1.03 x AREA CORRECTION FACTOR):

DURATION (HRS):	6	12	24	48	72
FACTOR (%) :	121	131	140	147	149

- HOB BROOK FACTOR (ADJUSTMENT FOR BASIN SHAPE AND FOR THE LESSER LIKELIHOOD OF A SEVERE STORM CENTERING OVER A SMALL BASIN) FOR A DRAINAGE AREA OF 2.22 SQUARE MILES IS 1.50.

(REF 4, P. 11)

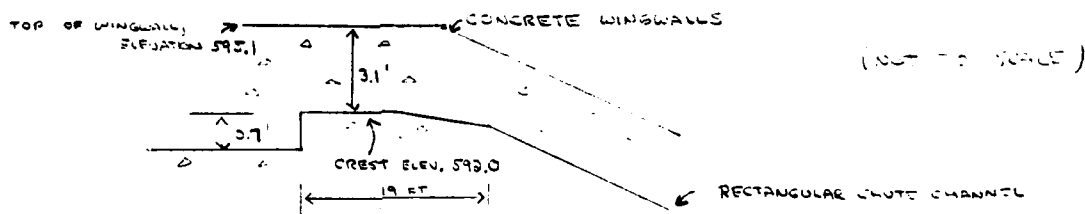
SUBJECT DAM SAFETY INSPECTION
HAWTHORNE DAM
 BY DJS DATE 1-4-80 PROJ. NO. 79-303-500
 CHKD. BY DLB DATE 1-8-80 SHEET NO. 7 OF 11

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SPILLWAY CAPACITY

PROFILE OF SPILLWAY:



(FROM FIELD NOTES, DESIGN DRAWING)

THE SPILLWAY IS A RECTANGULAR CONCRETE CHUTE CHANNEL
 WITH DISCHARGE CONTROLLED BY A BROAD-CRESTED WEIR. DISCHARGE
 OVER THE WEIR CAN BE ESTIMATED BY THE RELATION

$$Q = CLH^{3/2} \quad (\text{REF 5, p. 5-83})$$

WHERE Q = DISCHARGE, IN CFS,
 C = DISCHARGE COEFFICIENT,
 L = LENGTH OF SPILLWAY CREST = 17.4 FT,
 H = TOTAL HEAD ON CREST, IN FEET.

A DISCHARGE COEFFICIENT IN THE ORDER OF 0.67 WILL BE
 USED, BASED ON THE GEOMETRY OF THE WEIR. (IT IS ASSUMED THAT CRITICAL
 DEPTH OCCURS AT THE DOWNSTREAM END OF THE WEIR, OR AT THE BREAK
 IN SLOPE OF THE SPILLWAY CHANNEL.)

(REF 5, p. 5-85)

JECT DAM Safety Inspection
HAUSTONE DAM
 BY 2JS DATE 1-4-80 PROJ. NO. 79-307-TXJ
 CHKD. BY DLB DATE 1-8-80 SHEET NO. 8 OF 11



APPROACH LOSSES AND DOWNTOWN EFFECTS ARE ASSUMED TO BE
 AUTOMATIC HERE.

SPILLWAY RATING TABLE

RESERVOIR ELEVATION	H	Q *	RESERVOIR ELEVATION	H	Q
(FT)	(FT)	(CFS)	(FT)	(FT)	(CFS)
592.0	0	0	592.0	7.0	940
593.0	1.0	50	593.0	8.0	1320
594.0	2.0	150	594.0	9.0	1450
595.0	3.0	280	595.0	10.0	1700
(TOP OF DAM) 595.1	3.1	290	596.0	11.0	1900
596.0	4.0	430	597.0	12.0	2500
597.0	5.0	600	598.0	13.0	3530
598.0	6.0	790			

* $Q = CWH^{3/2} = (0.377)(17.4) H^{3/2}$
 $= 53.71 H^{3/2}$

PROJECT DAM SAFETY INTERVENTION
HAWSTONE DAM
 BY DJS DATE 1-4-80 PROJ. NO. 72-300-000
 CHKD. BY JLB DATE 1-8-80 SHEET NO. 9 OF 11

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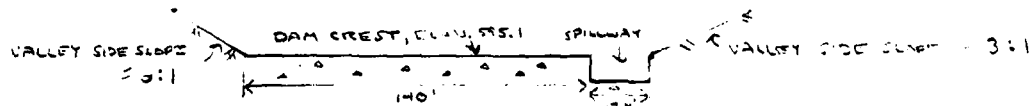
DAM CREST RATING CURVE

ASSUME THAT THE CREST OF THE DAM BEHAVES ESSENTIALLY AS A CRIPPLE-CRESTED WEIR WHEN OVERTOPPED. THUS, THE DISCHARGE CAN BE ESTIMATED BY THE EQUATION

$$Q = CLH^{3/2} \quad (\text{REF 5, p 5-23})$$

WITH Q, C, L, H AS DEFINED ON SHEET 7.

THE LENGTH OF THE CREST IS 140 FEET, AND THE EXCEEDTH IS 6 FEET. THE AVERAGE VALLEY SIDE SLOPE ADJACENT TO THE DAM IS APPROXIMATELY 2.5:1.



(NOT TO SCALE)

- SECTION LOOKING UPSTREAM -

(FROM FIELD NOTES

AND DIG TERS 2.2.1)

IT WILL BE ASSUMED THAT THE VELOCITY OF THE FLOW OVER THE SIDE-SLOPES IS EQUAL TO THE VELOCITY OVER THE DAM CREST, OR

$$V_s = V_c = \frac{Q_c}{Ac} = \frac{Q_c}{HL_c}$$

WHERE

V_s = VELOCITY OF FLOW OVER SIDE SLOPE (FT/SEC),

V_c = VELOCITY OF FLOW OVER CREST OF DAM (FT/SEC),

Q_c = DISCHARGE OVER DAM CREST (CFS),

L_c = LENGTH OF CREST = 140 FT,

H = HEAD (FT).

PROJECT DAM SAFETY INSPECTION
HAUNSTON DAM
 BY DTS DATE 1-4-80 PROJ. NO. 79-203-580
 CHKD. BY DLB DATE 1-8-80 SHEET NO. 10 OF 11



AND $Q_s = V_s A_s$,

WHERE Q_s = DISCHARGE OVER THE SIDE SLOPES (CFS),
 A_s = AREA OF FLOW OVER SIDE SLOPES (FT²)
 $= (2)(\frac{1}{3})(H)(2.5H)$
 $= 3.5 H^2$

$\therefore Q_{TC} = Q_c + Q_s$, WHERE Q_{TC} = TOTAL DISCHARGE OVER CREST (CFS).

RATING TABLE FOR CREST OF DAM:

RESTRICTOR ELEVATION (FT)	H (FT)	① C	② Q _c (CFS)	③ A _c (FT ²)	④ V _c = V _s (FPS)	⑤ A _s (FT ²)	⑥ Q _s (CFS)	⑦ Q _{TC} (CFS)
595.1	0	—	—	—	—	—	—	—
595.3	0.2	2.4	30	38	1.1	0	0	30
595.5	0.4	2.5	40	56	1.6	0	0	40
596.0	0.9	2.7	320	126	2.5	2	10	320
597.0	1.9	2.7	990	266	3.7	9	30	990
598.0	2.9	2.7	1870	406	4.6	31	100	1470
599.0	3.9	2.7	2910	546	5.3	38	200	2110
600.0	4.9	2.7	4350	686	6.2	60	370	2620
601.0	5.9	2.9	5820	926	7.0	87	610	3430
602.0	6.9	3.0	7610	966	7.9	119	940	4550

① ESTIMATED FROM REF. 5, TABLE 5-3.

② $Q_c = CLH^{3/2} = 140 CH^{3/2}$

③ $A_c = HL_c = 140 H$

④ $V_c = Q_c / A_c$

⑤ $A_s = 3.5 H^2$

⑥ $Q_s = A_s V_s$

⑦ $Q_{TC} = Q_c + Q_s$

PROJECT DAM SAFETY INSPECTIONS
HAWSTON LAM
 BY DJS DATE 1-4-80 PROJ. NO. 14-00-590
 CHKD. BY DLB DATE 1-8-80 SHEET NO. 11 OF 11



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TOTAL FACILITY RATING TABLE

$$Q_{TOTAL} = Q_{SPILLWAY} + Q_{DAM CREST}$$

RESERVOIR ELEVATION (FT)	Q _{SPILLWAY} (CFS)	Q _{DAM CREST} (CFS)	Q _{TOTAL} (CFS)
592.0	0	—	0
593.0	50	—	50
594.0	150	—	150
595.0	280	—	280
(TOP OF DAM) 595.1	290	0	290
595.3	320 *	30	350
595.5	350 *	90	440
596.0	430	330	760
597.0	600	1020	1620
598.0	790	1970	2760
599.0	990	2110	4100
600.0	1320	4620	5940
601.0	1450	6430	7880
602.0	1700	8550	10250

* - BY LINEAR INTERPOLATION.

PROJECT DAM SAFETY INSPECTION
HAWSTONE DAM
 BY RTS DATE 1-17-80 PROJ. NO. 79-203-580
 CHKD. BY DLB DATE 1-17-80 SHEET NO. A OF C



DAM SAFETY INSPECTION
HAWSTONE DAM *****
15-MINUTE TIME STEP AND 72-HOUR FLOOD DURATION *****

[illegible]

CONFIDENTIAL - SECURITY INFORMATION

[illegible]

ALL INFORMATION CONTAINED HEREIN

RESERVOIR INFLOW

[illegible]

U.S. AIR FORCE

[illegible]

1944-1945

Year	PMS	R6	R12	R24	R48	R96
1990	22.20	17.10	14.00	10.00	17.00	14.00
1991	22.20	17.10	14.00	10.00	17.00	14.00
1992	22.20	17.10	14.00	10.00	17.00	14.00
1993	22.20	17.10	14.00	10.00	17.00	14.00
1994	22.20	17.10	14.00	10.00	17.00	14.00
1995	22.20	17.10	14.00	10.00	17.00	14.00
1996	22.20	17.10	14.00	10.00	17.00	14.00
1997	22.20	17.10	14.00	10.00	17.00	14.00
1998	22.20	17.10	14.00	10.00	17.00	14.00
1999	22.20	17.10	14.00	10.00	17.00	14.00
2000	22.20	17.10	14.00	10.00	17.00	14.00
2001	22.20	17.10	14.00	10.00	17.00	14.00
2002	22.20	17.10	14.00	10.00	17.00	14.00
2003	22.20	17.10	14.00	10.00	17.00	14.00
2004	22.20	17.10	14.00	10.00	17.00	14.00
2005	22.20	17.10	14.00	10.00	17.00	14.00
2006	22.20	17.10	14.00	10.00	17.00	14.00
2007	22.20	17.10	14.00	10.00	17.00	14.00
2008	22.20	17.10	14.00	10.00	17.00	14.00
2009	22.20	17.10	14.00	10.00	17.00	14.00
2010	22.20	17.10	14.00	10.00	17.00	14.00
2011	22.20	17.10	14.00	10.00	17.00	14.00
2012	22.20	17.10	14.00	10.00	17.00	14.00
2013	22.20	17.10	14.00	10.00	17.00	14.00
2014	22.20	17.10	14.00	10.00	17.00	14.00
2015	22.20	17.10	14.00	10.00	17.00	14.00
2016	22.20	17.10	14.00	10.00	17.00	14.00
2017	22.20	17.10	14.00	10.00	17.00	14.00
2018	22.20	17.10	14.00	10.00	17.00	14.00
2019	22.20	17.10	14.00	10.00	17.00	14.00
2020	22.20	17.10	14.00	10.00	17.00	14.00
2021	22.20	17.10	14.00	10.00	17.00	14.00
2022	22.20	17.10	14.00	10.00	17.00	14.00
2023	22.20	17.10	14.00	10.00	17.00	14.00
2024	22.20	17.10	14.00	10.00	17.00	14.00
2025	22.20	17.10	14.00	10.00	17.00	14.00
2026	22.20	17.10	14.00	10.00	17.00	14.00
2027	22.20	17.10	14.00	10.00	17.00	14.00
2028	22.20	17.10	14.00	10.00	17.00	14.00
2029	22.20	17.10	14.00	10.00	17.00	14.00
2030	22.20	17.10	14.00	10.00	17.00	14.00
2031	22.20	17.10	14.00	10.00	17.00	14.00
2032	22.20	17.10	14.00	10.00	17.00	14.00
2033	22.20	17.10	14.00	10.00	17.00	14.00
2034	22.20	17.10	14.00	10.00	17.00	14.00
2035	22.20	17.10	14.00	10.00	17.00	14.00
2036	22.20	17.10	14.00	10.00	17.00	14.00
2037	22.20	17.10	14.00	10.00	17.00	14.00
2038	22.20	17.10	14.00	10.00	17.00	14.00

TASIC COMPLETED BY THE PROGRAM IS - HIGH

INITIAL AND CONSTANT RAINFALL
LOSSES AS PER COE

	STRIP	DITK4	RITOL	FUAIN	STANK	RETRON	SERIBL	TUSTED	AUSNA	HTIMP
LTRUPY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.00	0.00	0.00
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.00	0.00	0.00

BASE FLOW PARAMETERS
AS PER COE

TP = 1.10 CP = .55 CA = .0

REGRESSION DATA

```
STRTQ= -1.50  QRCN= -.05  RTOR= 2.00
```

APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE $TC = 4.90$ AND $RE = 5.17$ INCHES.

[illegible]

NO.	FILE	CLASS	RAIN	EACS	LUSS	COMP Q	MO. DA	IN. AM	PERIOD	RAIN	EACS	LOSS	COMP Q	1151.
									SUM	76.46	21.45	2.63		1151.
										(677.31	206.31	106.31		1151.

DAM SAFETY INSPECTION

HAWSTONE DAM

BY DJT DATE 1-17-82 PROJ. NO. 79-203-580

CHKD. BY DLB DATE 1-17-80 SHEET NO. B OF C



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0.3 PMF

O.4 PMF

0.5 PMF

HYDROGRAPH MOUNTING

ROUTE THROUGH RESERVOIR

STAGE	542.00	593.00	594.00	595.00	595.10	595.30	595.50	596.00	597.00	598.0
	593.00	600.00	601.00	602.00	602.00					
FLOW	0.00	50.00	150.00	280.00	290.00	350.00	440.00	500.00	1070.00	2760.00
	4100.00	5840.00	7800.00	10250.00						
CAPACITY	0.	7.	0.	1.	2.	3.	4.	6.	6.	
	5.	7.	1.	6.	4.	10.	12.			
ELEVATION	561.	565.	570.	575.	580.	585.	590.	593.	594.	
	595.	595.	596.	596.	600.	602.	605.			

DAM SAFETY INSPECTION

HAWSTONE DAM

BY DJS DATE 1-17-80 PROJ. NO. 79-203-580

CHKD. BY DLB DATE 1-17-80 SHEET NO. C OF C



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225. AT TIME 40.75 HOURS		0.3 PMF	
	PEAK	72-HOUR	TOTAL VOLUME
CFS	225.	14.	4121.
CAS	6.	0.	117.
INCHES		7.10	7.27
MM	5.63	180.35	184.64
AC-FT	143.00	83.	85.
THOUS CU M	66.	104.	105.
	81.		

229. AT TIME	40.75 HOURS	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL	VOLUME
CFS	299.		178.	56.	19.		5503.
CMS	8.		5.	2.	1.		152.
INCHES			7.51	9.47	9.70		9.70
MM			190.67	240.47	246.25		246.25
AC-FT			88.	111.	114.		114.
THOUS. LB. M			109.	137.	140.		140.

371. AT TIME 40.15 HOURS	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL	VOLUME
LF5	371.	222.	70.	24.	6874.	0.5 PMF
CMS	10.	6.	2.	1.	195.	
INCHES		4. IN	11.41	17.17	17.12	
MM		238.36	300.111	307.81	107.83	
AC-FE		110.	139.	142.	147.	
THOUS CU M		136.	171.	175.	175.	

SUMMARY OF DAM SAFETY ANALYSIS

RATIO OF DME	MAXIMUM RESERVE IN W.S. LEVEL	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM INFLUX CFS	POPULATION OVER TIME HOURS	TIME OF MAX OUTFLOW MINUTES	TIME OF FAILURE HOURS
.20	594.00	0.00	6.	150.	0.00	40.75	0.00
.30	594.58	0.00	6.	225.	0.00	40.75	0.00
.39*	595.10	—	7	290.	—	—	—
.40	595.13	.03	7.	299.	.50	40.75	0.00
.50	595.35	.25	7.	321.	1.50	40.75	0.00
.60	595.69	.49	7.	351.	4.50	40.75	0.00

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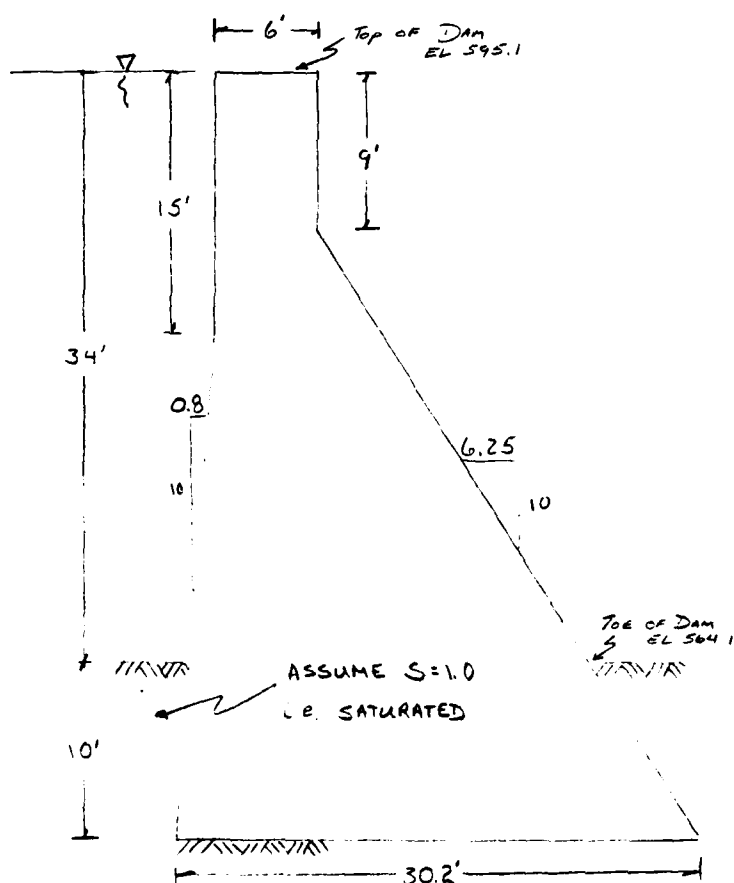
APPENDIX D-1
STABILITY CALCULATIONS

PROJECT DAM SAFETY INSPECTION
HAWSTONE DAM
 BY DLP DATE 1-11-80 PROJ. NO. 79-203-580
 CHKD. BY EJM DATE 1-17-80 SHEET NO. 1 OF 6

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STABILITY ANALYSIS

ANALYZE THE DAM CONSIDERING THE FOLLOWING SECTION.



ANALYSIS CONSIDERS POOL
 LEVEL AT TOP OF DAM.

FORCES INCLUDED IN THIS
 ANALYSIS ARE HYDROSTATIC
 PRESSURE, UPLIFT
 PRESSURE, AND WEIGHT
 OF DAM.

REF. FIGURE 4 AND
 FIELD MEASUREMENTS
 (SEE NOTE 2, SHEET 2)

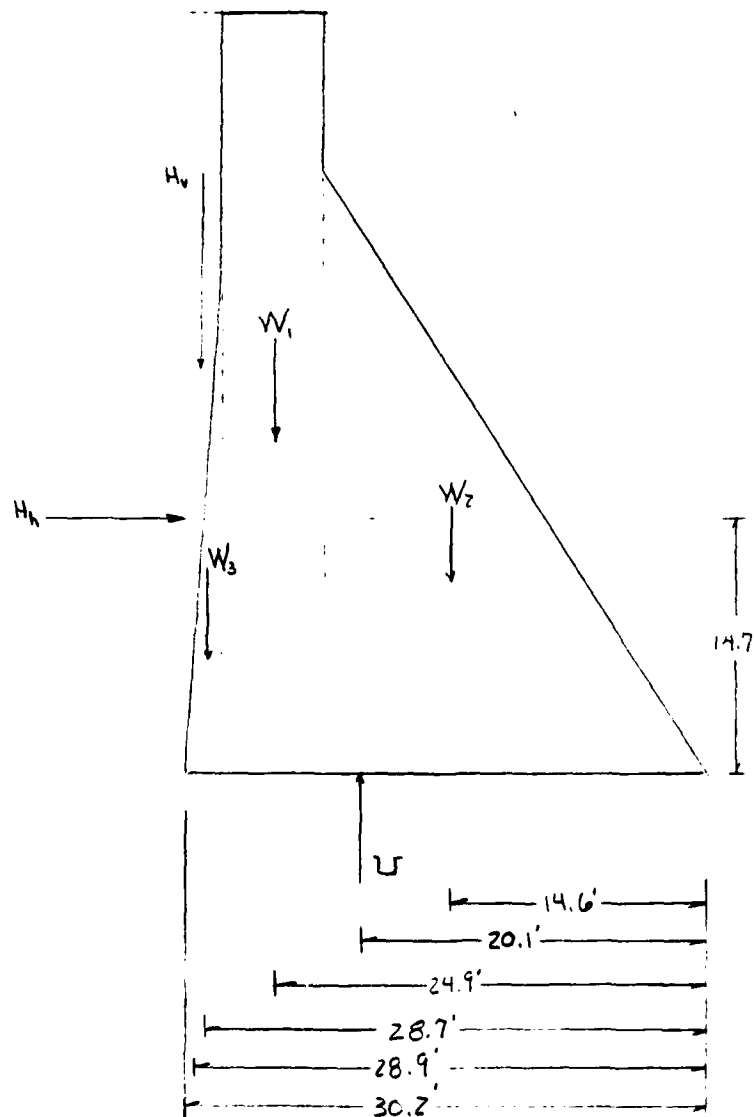
SCALE 1" = 10'

FORCES CONSIDERED, BUT NOT APPLIED TO THIS ANALYSIS INCLUDE WAVE
 PRESSURE, WIND PRESSURE, EARTHQUAKE FORCES, ICE PRESSURE, FOUNDATION
 RESISTANCES DUE TO TIES OR KEYS, AND EARTH PRESSURES (PARTICULARLY THE
 SHEAR STRENGTH OF ROCK AT THE TOE).

ECT DAM SAFETY INSPECTION
HAWSTONE DAM
 BY DLB DATE 1-11-80 PROJ. NO. 79-203-580
 CHKD. BY EJM DATE 1-17-80 SHEET NO. 2 OF 6

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ANALYZE A 1-FOOT SECTION OF THE DAM. TAILWATER WILL NOT BE CONSIDERED DUE TO THE STEEPNESS OF THE VALLEY SLOPE AND THE FACT THAT THE SPILLWAY DISCHARGES SAFELY DOWNSTREAM.



JECT DAM SAFETY INSPECTION
HAWSTONE DAM
 BY DLB DATE 1-11-80 PROJ. NO. 79-203-580
 CHKD. BY EJM DATE 1-17-80 SHEET NO. 3 OF 6



HYDROSTATIC FORCE ON FACE OF DAM

$$H_h = \gamma \left[\left(\frac{1}{2} \right) (h)^2 \right] T = (62.4 \text{ PCF}) \left[\left(\frac{1}{2} \right) (44 \text{ FT})^2 \right] (1.0 \text{ FT}) = 60,400 \text{ lbs}$$

UPLIFT PRESSURE ON BASE OF DAM

$$U = \gamma \left(\frac{1}{2} \right) (h_1 + h_2) T_b = (62.4 \text{ PCF}) \left(\frac{1}{2} \right) (44 \text{ FT} + 0) (1.0 \text{ FT}) (30.2 \text{ FT}) = 41,460 \text{ lbs}$$

WEIGHT OF WATER ON UPSTREAM FACE

$$H_v = \gamma \left[(2.3 \text{ FT}) (15 \text{ FT}) + \left(\frac{1}{2} \right) (2.3 \text{ FT}) (29 \text{ FT}) \right] (1.0 \text{ FT}) = 1,230 \text{ lbs}$$

WEIGHT OF DAM

$$W_1 = (150 \text{ PCF}) (1.0 \text{ FT}) (44 \text{ FT}) (6 \text{ FT}) = 39,600 \text{ lbs}$$

$$W_2 = (150 \text{ PCF}) (1.0 \text{ FT}) \left(\frac{1}{2} \right) (21.9 \text{ FT}) (35 \text{ FT}) = 57,490 \text{ lbs}$$

$$W_3 = (150 \text{ PCF}) (1.0 \text{ FT}) \left(\frac{1}{2} \right) (29 \text{ FT}) (2.3 \text{ FT}) = 5,000 \text{ lbs}$$

ALL FORCES ACT AS SHOWN ON SHEET 13.

PROJECT DAM SAFETY INSPECTION
HAWSTONE DAM
 BY DLB DATE 1-11-80 PROJ. NO. 79-203-580
 CHKD. BY EJM DATE 1-17-80 SHEET NO. 4 OF 6



OVERTURNING

INDUCING MOMENTS

$$M_1 = H_h (19.7 \text{ FT}) + U (20.1 \text{ FT}) = 1,721,230 \text{ LB-FT}$$

RESISTING MOMENTS

$$\begin{aligned}
 M_2 &= W_1 (24.9 \text{ FT}) + W_2 (14.6 \text{ FT}) + W_3 (28.7 \text{ FT}) + H_v (28.9 \text{ FT}) = \\
 &= 986,040 + 839,350 + 143,500 + 122,250 = 2,091,140 \text{ LB-FT}
 \end{aligned}$$

FACTOR OF SAFETY AGAINST OVERTURNING

$$\begin{aligned}
 \text{F.S.} &= \frac{\text{RESISTING MOMENTS}}{\text{INDUCING MOMENTS}} \\
 &= \frac{2,091,140 \text{ LB-FT}}{1,721,230 \text{ LB-FT}} = 1.2
 \end{aligned}$$

SLIDING

INDUCING FORCE

$$H_h = 60,400 \text{ LBS}$$

RESISTING FORCE

$$F_f = \mu (W_4 - U + H_v)$$

IECT DAM SAFETY INSPECTION
HAWSTONE DAM
 BY DLB DATE 1-11-80 PROJ. NO. 79-203-580
 CHKD. BY EJM DATE 1-17-80 SHEET NO. 5 OF 6



μ = FRICTION FACTOR = 0.67 (AS PER DESIGN CALCS
 CONTAINED IN PENNDER FILES)

W_T = TOTAL WEIGHT OF CONCRETE
 $= W_1 + W_2 + W_3 = 39,600 + 57,490 + 5000 = 102,090 \text{ Lbs}$

U = UPLIFT FORCE = 41,466 Lbs

$F_f = (0.67)(102,090 - 41,460 + 4230) \text{ Lbs} = 43,460 \text{ Lbs}$

FACTOR OF SAFETY AGAINST SLIDING

$$\text{F.S.} = \frac{\text{RESISTING FORCE}}{\text{INDUCING FORCE}} = \frac{43,460 \text{ Lbs}}{60,400 \text{ Lbs}} = 0.7$$

THE ABOVE CALCULATED SAFETY FACTORS FOR SLIDING (0.7) AND
 OVERTURING (1.2) DO NOT COMPARE FAVORABLY WITH GENERALLY
 ACCEPTED FACTORS OF 1.0 TO 1.5 FOR SLIDING AND ABOUT 2.0
 FOR OVERTURING (REF 16, pg 200).

ORIGINAL DESIGN DATA CONTAINED IN PENNDER FILES
 INDICATES THAT THE DESIGNER DID NOT CONSIDER UPLIFT
 PRESSURES EXERTED ON THE BASE OF THE STRUCTURE.
 THE REASONING BEHIND THIS DELETION IS UNCLEAR. THE
 RESULT OF ALLOWING U TO APPROACH ZERO IS PRESENTED
 ON THE FOLLOWING PAGE.

SUBJECT DAM SAFETY INSPECTION
HAWSTONE DAM
BY DLB DATE 1-11-80 PROJ. NO. 79-203-580
CHKD. BY EJM DATE 1-17-80 SHEET NO. 6 OF 6



OVERTURNING (U → O)

INDUCING MOMENTS

$$M_1 = H_h (14.7 \text{ ft}) = 887,880 \text{ lb-ft}$$

RESISTING MOMENTS

$$M_2 = 2,091,140 \text{ lb-ft}$$

$$\text{F.S.} = \frac{M_2}{M_1} = \frac{2,091,140 \text{ lb-ft}}{887,880 \text{ lb-ft}} = 2.4$$

SLIDING (U → O)

INDUCING FORCE

$$H_h = 60,400 \text{ lbs}$$

RESISTING FORCE

$$F_f = \mu (W_f + H_v) = (0.67)(102,090 + 4230) \text{ lbs} = 71,230 \text{ lbs}$$

$$\text{F.S.} = \frac{F_f}{H_h} = \frac{71,230 \text{ lbs}}{60,400 \text{ lbs}} = 1.2$$

APPENDIX E

FIGURES

LIST OF FIGURES

<u>Figure</u>	<u>Description/Title</u>
1	Regional Vicinity and Watershed Boundary Map
2	General Plan
3	Longitudinal Section
4	Outlet and Spillway Cross Sections
5	Reservoir Plan

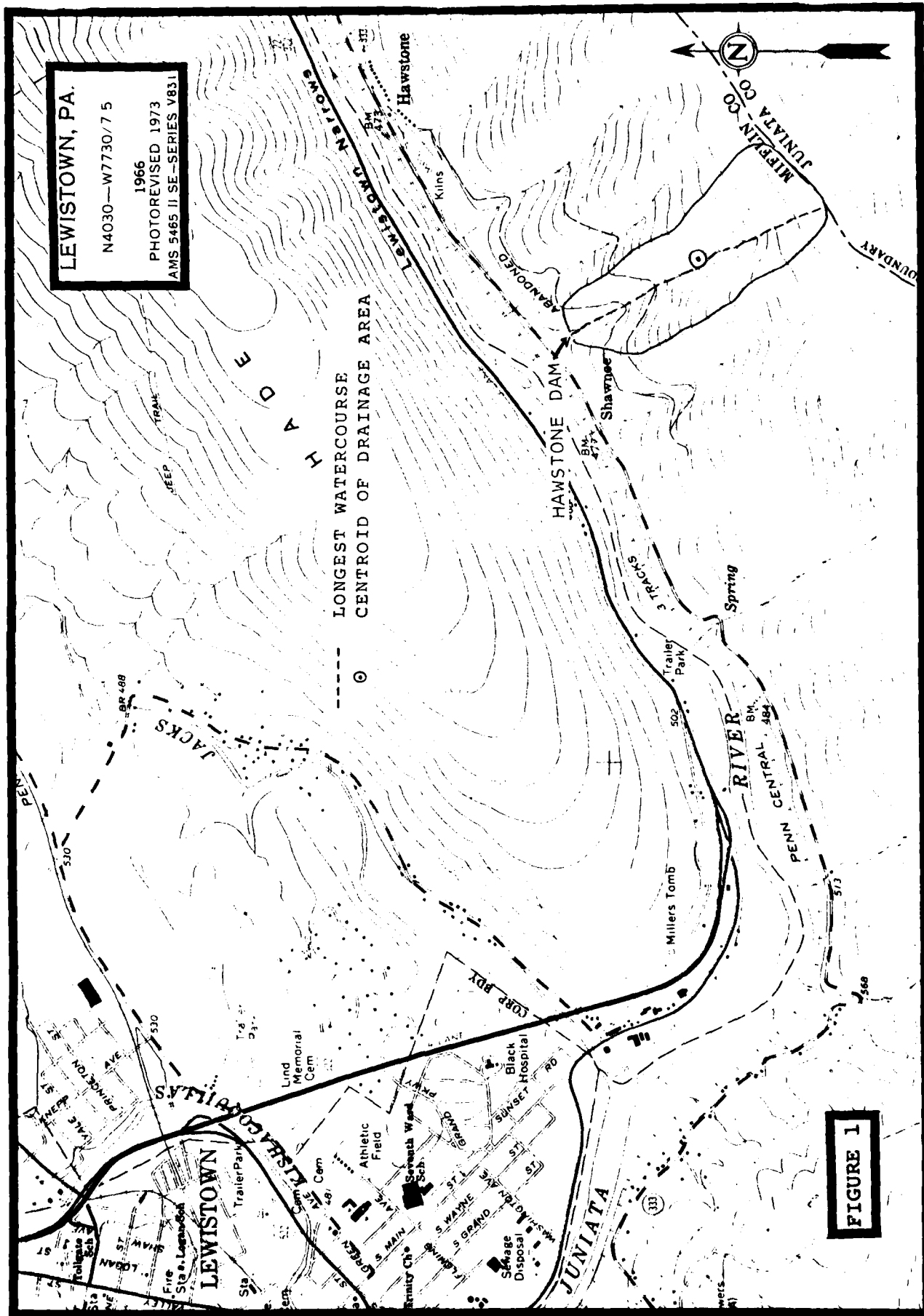
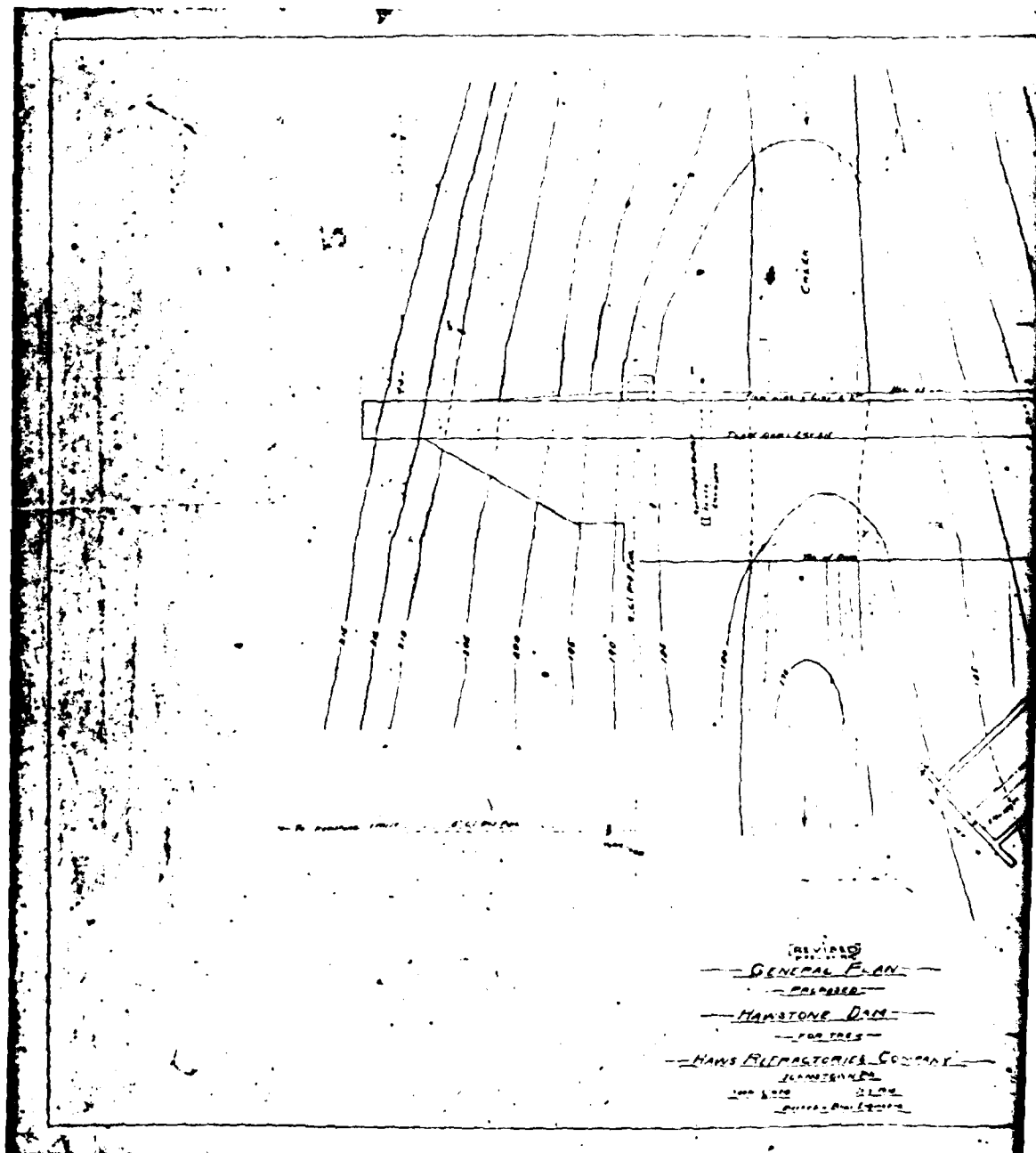
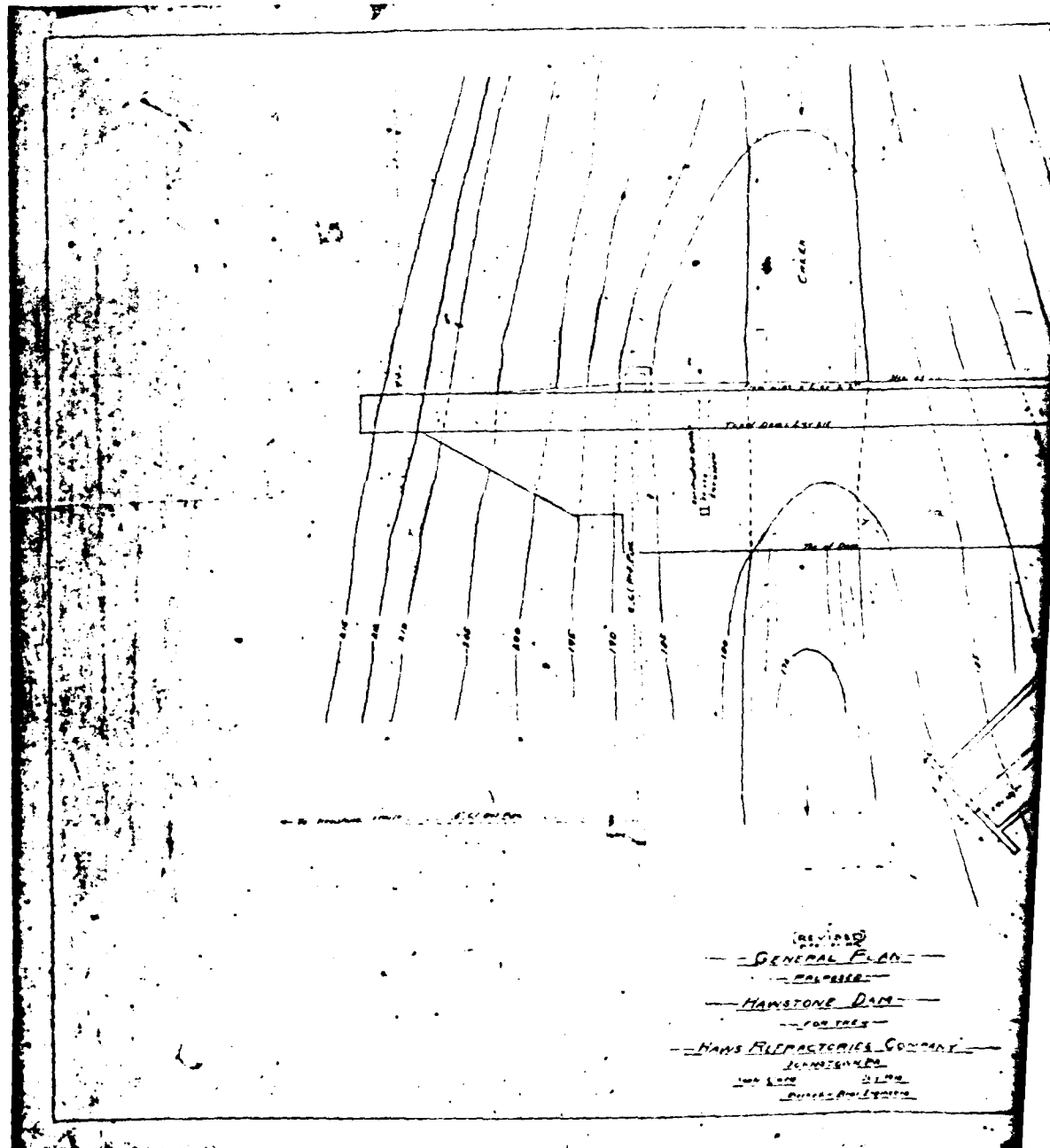
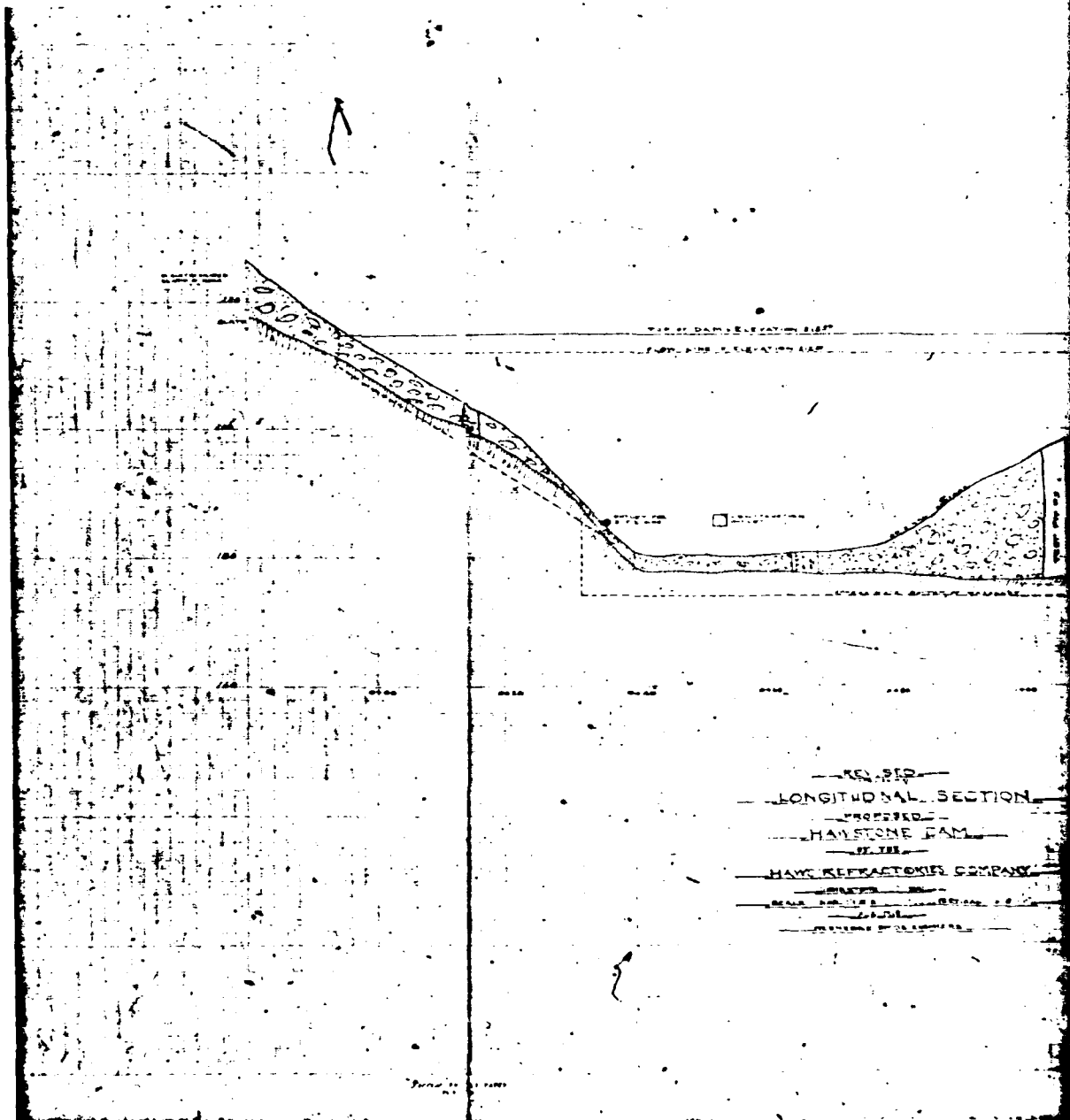
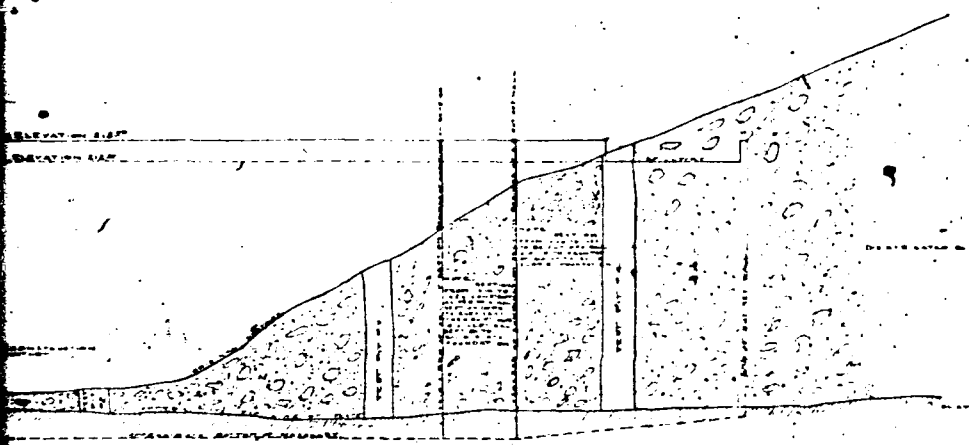


FIGURE 1

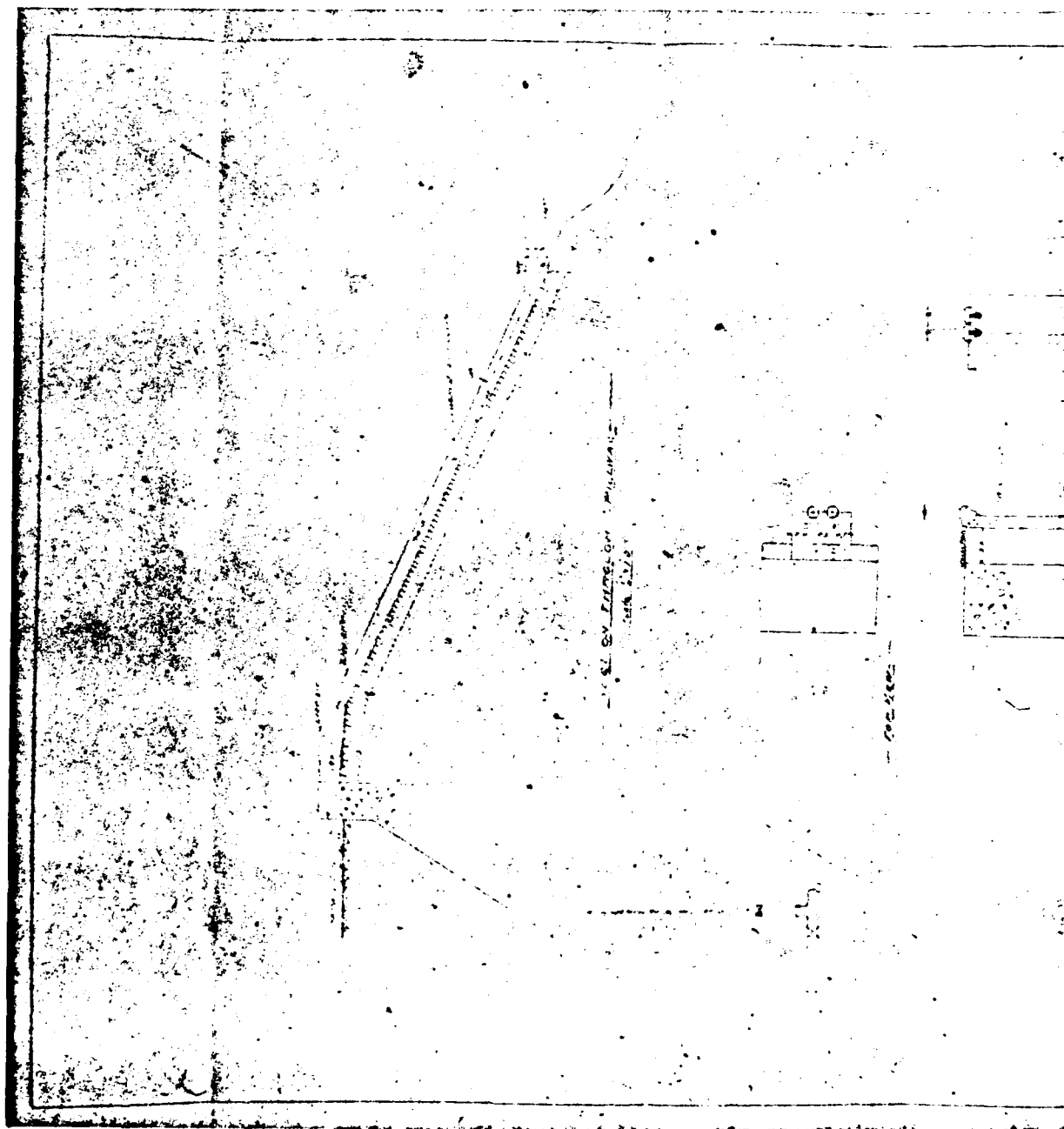


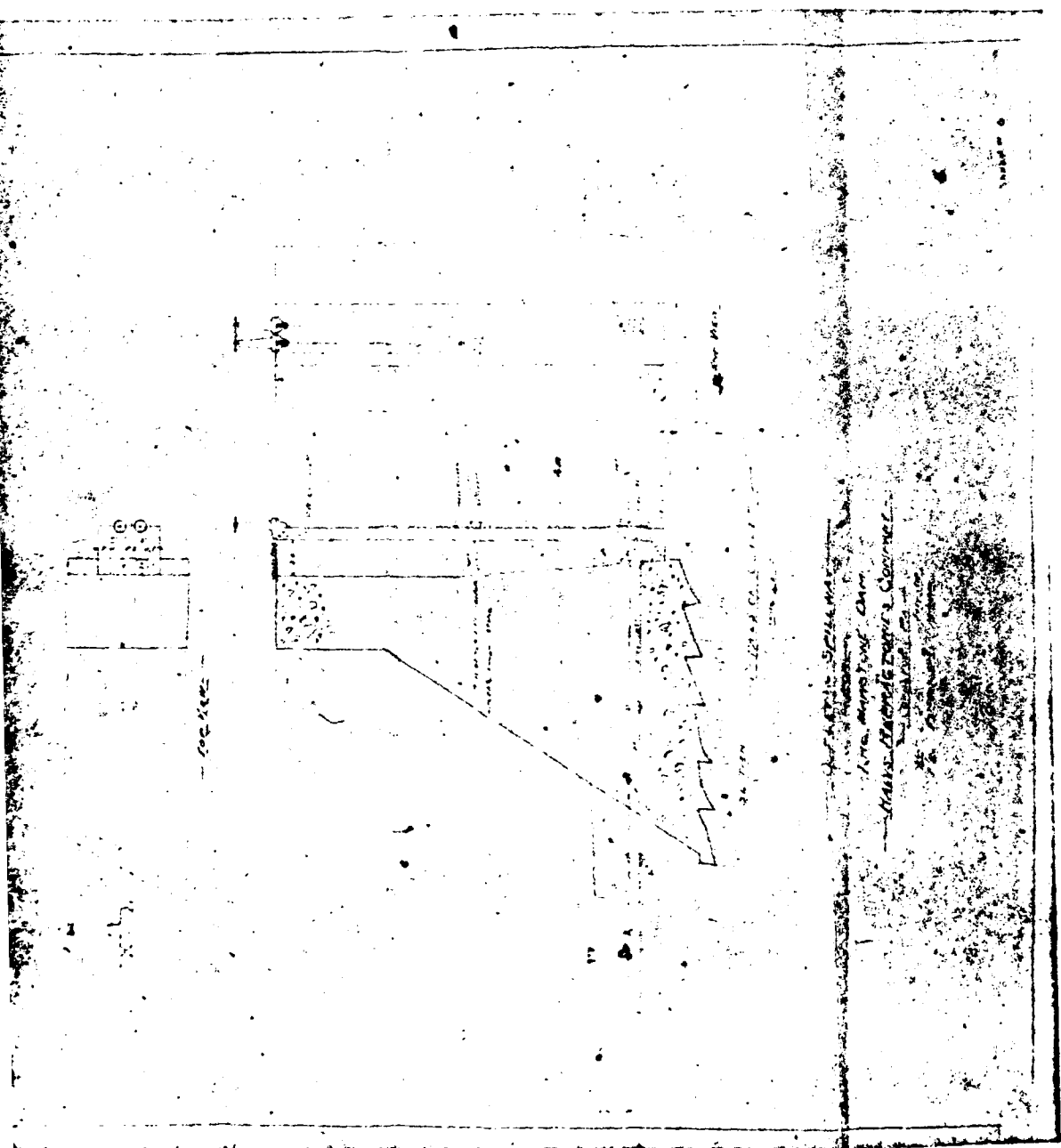


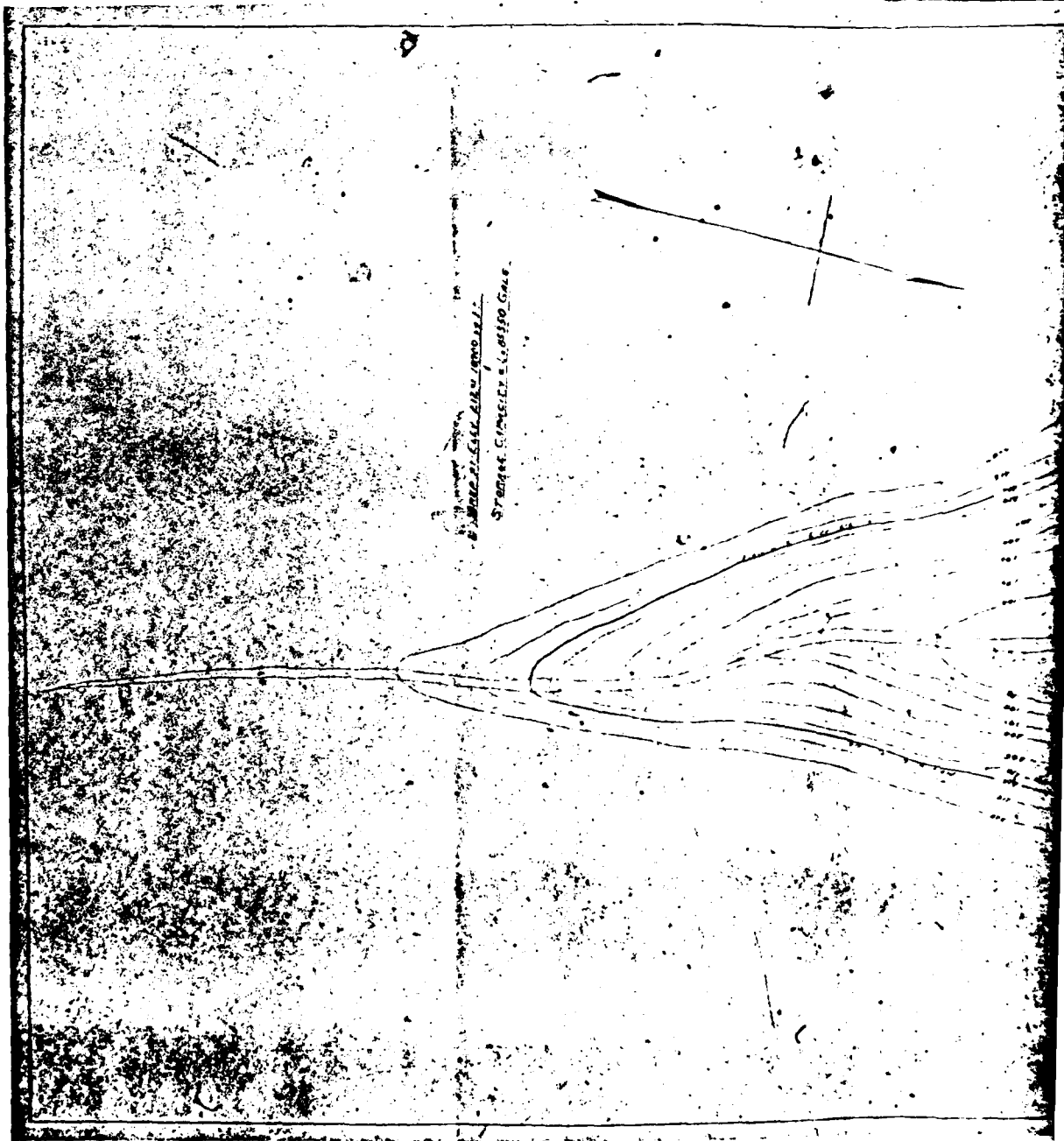


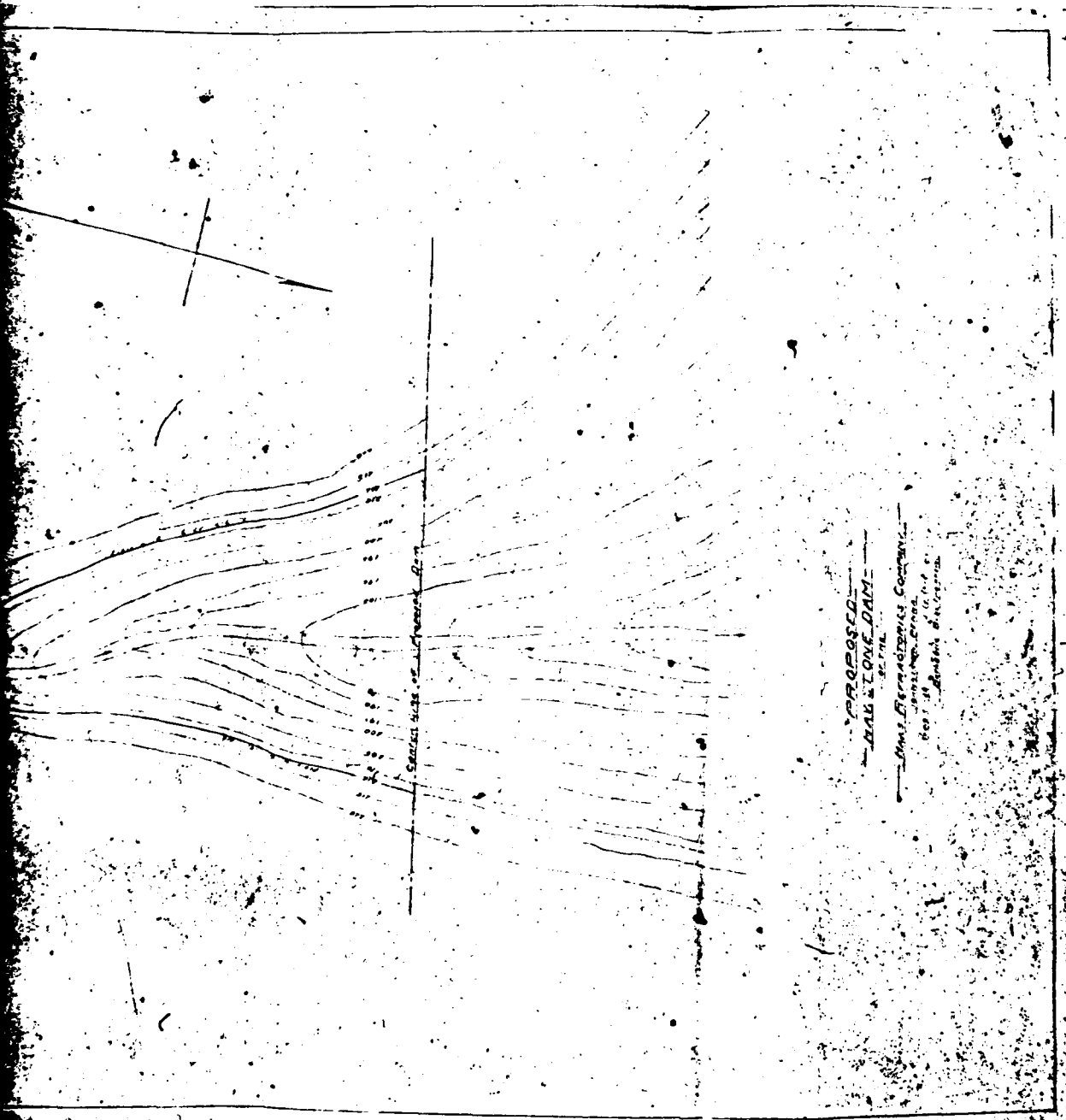


100.00
 LONGITUDINAL SECTION
 PROPOSED
 HAYSTONE DAM
 10.00
 HAWK REFRAC TOXIES COMPANY
 10.00
 SCALE 1" = 10' HORIZONTAL
 1" = 10' VERTICAL
 10.00









APPENDIX F

GEOLOGY

Geology

Hawstone Dam is located about 1 mile west of Hawstone, Pennsylvania on an unnamed tributary to the Juniata River, in the Valley and Ridge physiographic province of the Appalachian Mountain Section of central Pennsylvania. This tributary is located on the northwest flank of Blue Mountain which rises approximately 1,400 feet to the southeast above the dam.

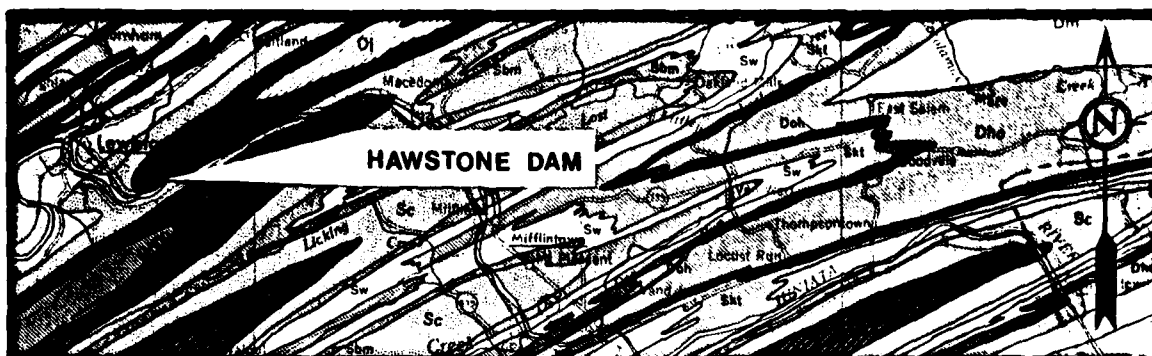
Structurally, the dam lies in the Lewistown Narrows of the Lewistown Valley synclinorium, a major northeast-southwest trending structure that can be traced for nearly 40 miles. In the Lewistown area, folding generally increases in intensity producing a complex group of northeast-southwest trending folds. Many of the component folds, especially along the southern flank of the synclinorium, are plunging. There is little evidence of major faulting in the vicinity of the dam.

At the dam site, the bedrock dips away from the downstream face of the dam at nearly 80 degrees, while the strike is approximately parallel with the dam axis. The bedrock immediately underlying the dam and reservoir consists of a Silurian age shale probably representing the Clinton Group. This thinly bedded shale is reddish-purple to greenish-gray in color and is interfingered with "iron sandstone" and local gray, fossiliferous limestone. Above

the dam lies a quartzitic sandstone, probably representing the Tuscarora formation, which is of some economic importance and has been locally quarried.

¹Colin, Richard R. and Hoskins, Donald M., "Geology and Mineral Resources of the Mifflintown Quadrangle Pennsylvania," Pennsylvania Geological Survey, Fourth Series, ATLAS A 126, 1962.

²Lohman, Stanley W., "Groundwater in South Central Pennsylvania," Pennsylvania Geological Survey, Fourth Series, Bulletin W5, 1938.



LEGEND

DEVONIAN

- Dck** Catskill Formation
Chiefly red to brownish shales and sandstones; includes gray and greenish sandstone tongues named Elk Mountain, Honendale, Shohola, and Delaware River in the east.
- Dm** Marine beds
Gray to olive brown shales, graywackes, and sandstones; contains "Chemung" beds and "Portage" beds including Burket, Brallier, Harrell, and Trimmers Rock; Tully Limestone at base.

MIDDLE AND LOWER

- Mahantango Formation**
Brown to olive shale with interbedded sandstones which are dominant in places (Montebello); highly fossiliferous in upper part; contains "Centerfield coral bed" in eastern Pennsylvania.
- Marcellus Formation**
Black, fissile, carbonaceous shale with thick, brown sandstone (Turkey Ridge) in parts of central Pennsylvania.
- Onondaga Formation**
Greenish blue, thin bedded shale and dark blue to black, medium bedded limestone with shale predominant in most places; includes Selinacove Limestone and Needmore Shale in central Pennsylvania and Butterfield Falls Limestone and Escopus Shale in easternmost Pennsylvania; in Lehigh Gap area includes Palmerton Sandstone and Bowmanstown Chert.
- Oriskany Formation**
White to brown, fine to coarse grained, partly calcareous, locally conglomeratic, fossiliferous sandstone (Ridgeley) at the top; dark gray, cherty limestone with some interbedded shales and sandstones below (Shriver).
- Helderberg Formation**
Dark gray, calcareous, thin bedded shale (Mandata) at the top, equivalent to First Even Shale and Hecraft Limestone in the east; dark gray, cherty, thin bedded, fossiliferous limestone (New Scotland) with some local sandstones in the middle; and, at the base, dark gray, medium to thick bedded, crystalline limestone (Crimmon), sandy and shaly in places with some chert nodules.

SILURIAN

- Keyser Formation**
Dark gray, highly fossiliferous, thick bedded, crystalline to nodular limestone; passes into Manlius, Rondout, and Decker Formations in the east.
- Tonoloway Formation**
Gray, highly laminated, thin bedded, argillaceous limestone; passes into Foxcroftville and Pozono Island beds in the east.

- Wills Creek Formation**
Greenish gray, thin bedded, fissile shale with local limestone and sandstone zones; contains red shale and siltstone in the lower part.

- Bloomsburg Formation**
Red, thin and thick bedded shale and siltstone with local units of sandstone and thin impure limestone, some green shale in places.

- Clinton Group**
Predominantly Rose Hill Formation - Reddish purple to greenish gray, thin to medium bedded, fossiliferous shale with intertonguing "iron sandstones" and local gray, fossiliferous limestone; above the Rose Hill is brown to white quartzitic sandstone (Kierulff) interbedded upward with dark gray shale (Rochester).

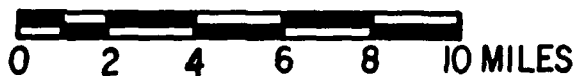
- Tuscarora Formation**
White to gray, medium to thick bedded, fine grained, quartzitic sandstone, conglomeratic in part.

ORDOVICIAN

- Juniata Formation**
Red, fine grained to conglomeratic, quartzitic sandstone with well developed cross-bedding and with interbedded red shale in places.

- Bald Eagle Formation**
Gray to greenish gray, fine grained to conglomeratic, thick bedded sandstone; often iron-speckled and cross-bedded; some greenish gray shale in places.

Scale



REFERENCE:

GEOLOGIC MAP OF PENNSYLVANIA PREPARED BY COMMONWEALTH OF PENNA. DEPT. OF INTERNAL AFFAIRS, DATED 1960, SCALE 1" = 4 MILES

GEOLOGY MAP

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