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NATIONAL DAM SAFETY PROGRAM. HAVEN LAKE DAM (DE00042), MISPILLI--ETC(U)
JUN 78 J J WILLIAMS DACW61-78-C-0052

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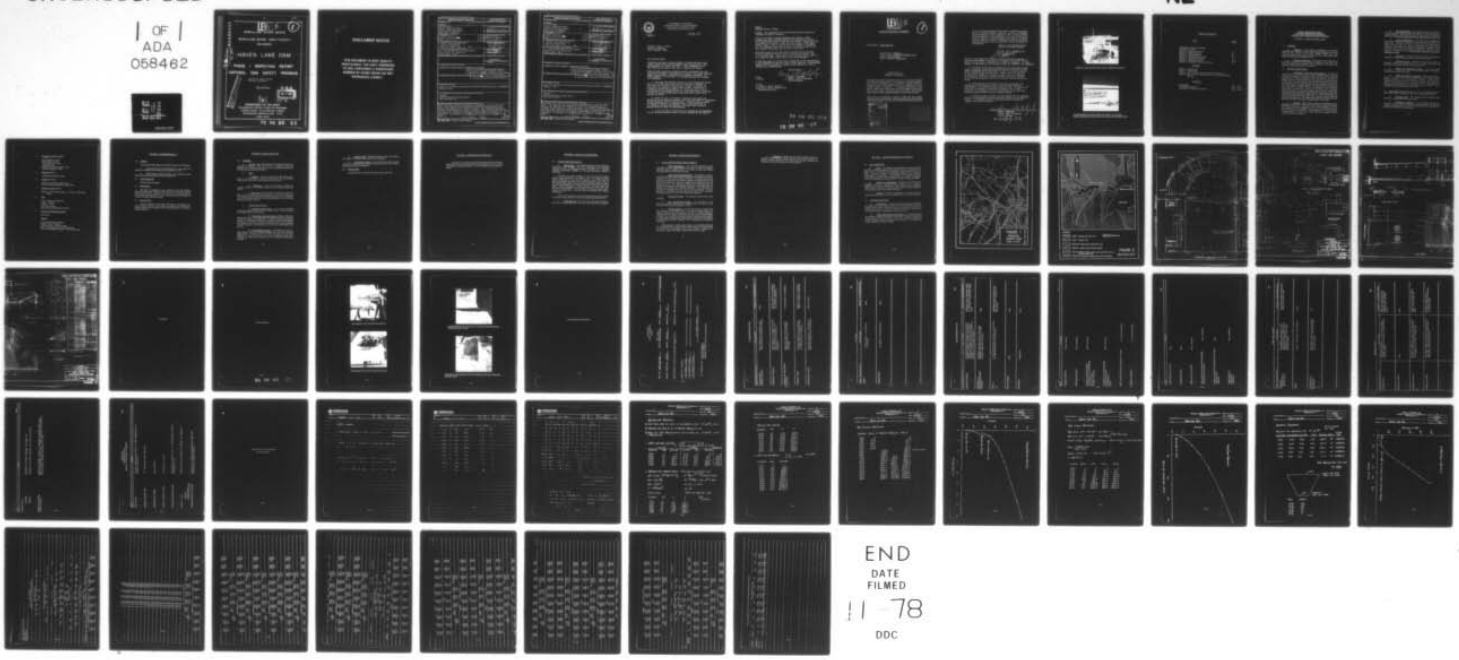

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LEVEL II

MISPILLION RIVER BASIN

MISPILLION RIVER, KENT COUNTY

DELAWARE, MD

HAVEN LAKE DAM (DE00042)

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

Approved for public release;
distribution unlimited

DE00042

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106
JUNE 1978

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: DE00042	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: Phase I Inspection Report National Dam Safety Program Haven Lake Dam (DE00042) Kent County, Delaware	5. TYPE OF REPORT & PERIOD COVERED: (9) Final rept.
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): (10) John J. Williams [redacted]	8. CONTRACT OR GRANT NUMBER(s): (15) DACW61-78-C-0052
9. PERFORMING ORGANIZATION NAME AND ADDRESS: O'Brien & Gere Engineers Inc. Justins & Courtney Div. 1617 J.F.K. Blvd. Phila. Pa. 19103	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: (12) 61p
11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. Army Engineer District, Philadelphia Custom House, 2d & Chesnut Sts. Phila. Penna. 19106	12. REPORT DATE: (11) Jun[redacted]78
	13. NUMBER OF PAGES: 57
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	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

(6) National Dam Safety Program. Haven Lake Dam (DE00042), Mispillion River Basin, Mispillion River, Kent County, Delaware, [redacted] Phase 1 Inspection Report.

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia, 22151.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Dams-Del.
National Dam Safety Program Phase I
Haven Lake Dam, Del.

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

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. As assessment of the dam;s general condition is included in the report.

dam's 410 760

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DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-D

28 JUL 1978

Honorable Pierre S. DuPont
Governor of Delaware
Dover, Delaware 19901

Dear Governor DuPont:

Inclosed is the Phase I Inspection Report for Haven Lake Dam in Kent County, Delaware which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given on the first two pages of the report.

Based on visual inspection, available records, calculations and past operational performance, Haven Lake Dam is judged to be in good condition. However, the spillway is considered to be seriously inadequate. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. Hydrologic and hydraulic investigations and engineering studies should be initiated within three months of the date of approval of this report to determine corrective action required to increase the capacity of the spillway to pass at least 1/2 PMF. Construction of an improved spillway should commence in calendar year 1979. Due to the potential for overtopping of the dam, a detailed emergency operation, drawdown and warning system should be developed by the owner within the next two months.

b. Within one year of the date of approval of this report the undermining of the downstream concrete lined left bank should be investigated and any necessary corrective action taken. In addition the pool should be temporarily lowered at a convenient time to allow inspection of the leakage of the stop logs adjacent to the right bank, corrective measures should be taken if found necessary.

c. At the next time of no flow over the spillway and low downstream flow the spillway structure should be further examined for any signs of

distress. The downstream weir's notches should also be checked for clogging and cleared if required.

A copy of the report is being furnished to Mr. Austin P. Olney, Delaware Department of Natural Resources and Environmental Control, the designated State Office contact for this Program. Within five days of the date of this letter, a copy will also be sent to Congressman Thomas B. Evans. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, thirty days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia, 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely yours,

Harry V. Dutchyshyn

HARRY V. DUTCHYSHYN
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Cy Furn:
Mr. Austin P. Olney, Secretary
Department of Natural Resources and
Environmental Control

LEVEL II

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam: Haven Lake Dam

State Located: Delaware
County Located: Kent County/Sussex County
Stream: Mispillion River
Date of Inspection: May 24, 1978

ASSESSMENT OF GENERAL CONDITIONS

The Haven Lake Dam consists of a semi-circular concrete spillway with four sluiceways provided for flood control. The spillway/sluiceway structure is integrally tied to the abutments and embankments of a highway bridge. The embankments can be considered as the non-overflow section of the dam. A complete examination of the structure could not be made at the time of the inspection since one to three inches of water was flowing over the spillway. The concrete structures that could be inspected appeared to be in good condition.

There were no detrimental findings to render the dam unsafe. However, Hydraulics/Hydrologic analyses reveal that the embankments would be overtopped for all storms exceeding approximately eight (8)

per cent of Probable Maximum Flood (PMF); therefore, the spillway can be considered "seriously inadequate" as cited in Engineering Technical Letter No. 1110-2, January 25, 1978. In order to satisfy criteria established by the Department of the Army, Office of the Chief of Engineers, remedial measures that should be considered include increasing the length of the spillway structure and providing an additional waterway to pass at least ½PMF without overtopping the embankments.

O'BRIEN & GERE ENGINEERS, INC.
JUSTIN & COURTNEY DIVISION

John J. Williams

John J. Williams, P.E.
Vice President

Based on visual inspection, available records, calculations andppast operational performance, Haven Lake Dam is judged to be in good condition However, the spill way is considered to be seriously inadequate. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. Hydrologic and hydraulic investigations and engineering studies should be initiated within three months of the date of approval of this report to determine corrective action required to increase the capacity of the spillway to pass at least ½ PMF. Construction of an improved spillway should commence in calendar year 1979. Due to the potential for overtopping of the dam, a detailed emergency operation, drawdown and warning system should be developed by the owner within the next two months.

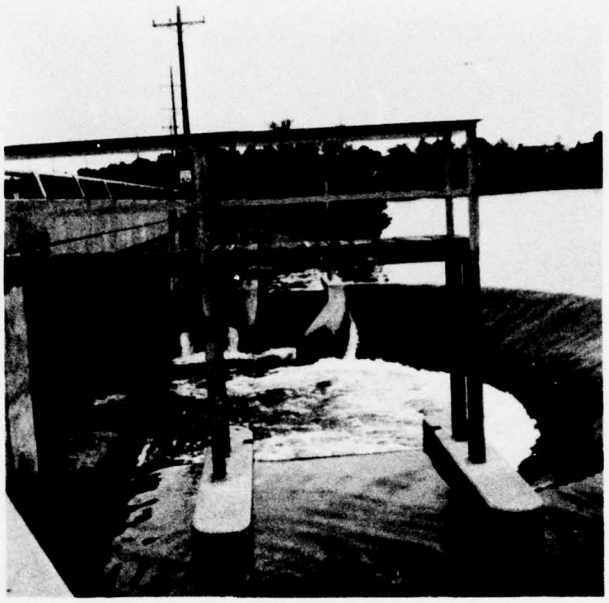
b. Within one year of the date of approval of this report the undermining of the downstream concrete lined left bank should be investigated and any necessary corrective action taken. In addition the pool should be temporarily lowered at a convenient time to allow inspection of the leakage of the stop logs adjacent to the right bank, corrective measures should be taken if found necessary.

c. At the next time of no flow over the spillway and low downstream flow the spillway structure should be further examined for any signs of distress. The downstream weir's notches should also be checked for clogging and cleared if required.

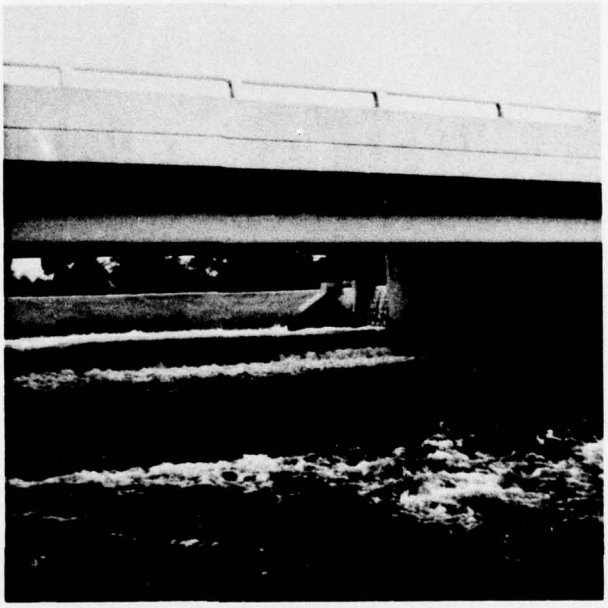
APPROVED: Harry V. Dutchyshyn

HARRY V. DUTCHYSHYN
Colonel, Corps of Engineers
District Engineer

DATE: 28 July 1978



OVERALL VIEW OF SPILLWAY AND ACCESS WALKWAYS



DOWNSTREAM VIEW SHOWING SPILLWAY, SLUICEWAY,
WIER, CONCRETE APRON AND SOUTHBOUND BRIDGE SPAN

TABLE OF CONTENTS

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NAME OF DAM HAVEN LAKE DAM ID# 00042

SECTION I - PROJECT INFORMATION

1.1 GENERAL

a. Authority - This report is authorized by the Dam Inspection Act, Public Law 92-367, and has been prepared in accordance with contract #DACW 61-78-C-0057 between O'Brien and Gere Engineers, Justin and Courtney Division and the United States Army Corps of Engineers, Philadelphia District.

b. Purpose of Inspection - The purpose of this inspection is to evaluate the structural and hydraulic condition of the Haven Lake Dam and appurtenant structures and to determine if the dam constitutes a hazard to human life or property.

1.2 PROJECT DESCRIPTION

a. Description of Dam and Appurtenances - The dam at Haven Lake is principally a semi-circular concrete spillway provided with four sluiceways. According to plans furnished by the Delaware Department of Natural Resources and Environmental Control, the spillway section is approximately 110 feet long with a maximum height of 7.42 feet. Two sluiceways are provided on both ends of the spillway. Each sluiceway has a maximum opening of approximately 39 square feet and is controlled by wooden stop logs. The spillway/sluiceway structure (see Figure #3) is integrally tied to the abutments of the southbound bridge span of Route #113. During the inspection, flow was passing over the spillway and sluiceway stoplogs and under the bridge span. Downstream of the spillway, at approximately the upstream face of the southbound bridge span, flow passes over a 1.5 feet twin-notched weir and a 1.0 foot thick concrete apron which lines the channel under the southbound bridge span. Flow then passes under the northbound bridge span of Route #113 to an open channel leading to Silver Lake.

b. Location - Haven Lake is located on the Mispillion River upstream of Silver Lake. Both of these reservoirs are situated upstream of Milford, Delaware, a community with a 1970 population of 5,314. The centerline of the Mispillion River serves as the border between Kent County and Sussex County. The drainage area of 30 square miles is approximately 7 miles long, 4 miles wide and is situated entirely within the State of Delaware .

c. Size Classification - The maximum height of the dam is 7.42 feet and the reservoir volume to the spillway crest is approximately 242 acre feet. Therefore, the dam is in the small size category as defined by the Recommended Guidelines For Safety Inspection of Dams.

d. Hazard Classification - No significant development is present just downstream of Haven Lake since this reservoir empties into Silver Lake. However, a failure of Haven Lake Dam may cause a failure of Silver Lake Dam, thereby endangering the population and industrial, commercial and residential development in Milford. Therefore, the Haven Lake Dam should be classified in the high hazard category as defined by the Recommended Guidelines For Safety Inspection of Dams.

e. Ownership - The dam is owned by the State of Delaware, Department of Natural Resources and Environmental Control.

f. Purpose of Dam - Information provided by State of Delaware Officials listed the purposes of the Haven Lake Dam and Reservoir as irrigation, recreation and flood control.

g. Design and Construction History - No other details pertaining to "Construction History" were made available. The present structure was completed in 1956.

h. Normal Operational Procedures - Haven Lake Dam is operated by the Division of Fish and Wildlife, Delaware Department of Natural Resources and Environmental Control. Under normal conditions, the water surface is maintained at Elevation 14.88 MSL, slightly above the spillway crest elevation of 14.82. This results in a discharge of approximately 3.5 million gallons per day (MGD). The top elevation of the wooden stop logs is at 14.96.

1.3 PERTINENT DATA (Drawings #1, 2, 3, & 8 through 23 of 26 entitled U.S. Route 113 Bridge at Haven Lake dated April 27, 1961).

a. Drainage Area - The drainage area for Haven Lake Reservoir is approximately 30 square miles.

b. Discharge at Damsite - The maximum flow at the damsite is unknown since no records were made available. The spillway capacity is approximately 3,230 cfs with the reservoir water surface at the minimum elevation of the roadway.

c. Elevation (Feet above MSL)

Top of Spillway - 14.82
Normal Pool - 14.88
Top of Stop Logs - 14.96
Tailwater - 8.40
Concrete Downstream Apron - 7.40
Minimum Roadway - 19.20

d. Reservoir (miles)

Length of Normal Pool - 0.86

e. Storage (acre feet)

Spillway Crest (Normal Pool) = 242
Minimum Roadway (Maximum Pool) = 390

f. Reservoir Surface (acres)

Spillway Crest (Normal Pool) = 42 (from USGS Quad Sheet)

g. Dam

Type - Highway Embankment
Length - 810 feet
Height - 11 feet
Top Width - 42 feet
Sheet Piling under Spillway Concrete

h. Diversion and Regulating Tunnel

None exists

i. Spillway

Type - Semi-circular overflow
Length of Weir - 110 feet
Crest Elevation - 14.82 feet (MSL)
Gates - 4 sluiceways with wooden stop logs
Flow Area with gates full open = 155.34 square feet

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

The available data relative to the dam consists of the following:

a. Drawings No. 1,2,3 and 8 through 23 of 26 entitled U.S. ROUTE 113 BRIDGE AT HAVEN LAKE dated April 27, 1961.

b. Water-Table, Surface-Drainage and Engineering Soils Map of the Milford Quadrangle, Delaware dated 1964.

2.2 CONSTRUCTION

No information available

2.3 OPERATION

The dam is operated by the Division of Fish and Wildlife, Delaware Department of Natural Resources and Environmental Control. When severe flooding conditions are expected, the stop logs can be removed from the sluiceways in order to lower the level of the lake and to allow for additional flood storage.

2.4 EVALUATION

Although additional information pertaining to foundation conditions would be helpful to fully assess the condition of the dam, the design drawings made available were considered adequate for a Phase I Inspection Report.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General - The visual inspection of Haven Lake Dam was conducted on May 24, 1978. At the time of inspection, water was flowing over the spillway and stop logs at an elevation approximately 0.2 feet above normal pool elevation.

b. Dam

1) Spillway - Since the spillway was discharging at the time of the inspection, a complete investigation was not possible. However, the flow pattern over the spillway was uniform.

2) Sluiceways - The four sluiceways provided for drawdown appear to be in good condition with no serious deficiencies visible.

3) Stop Logs - Each sluiceway is fitted with timber stop logs. The stop logs are manually positioned to control pool elevation. The stop logs in the sluiceway immediately adjacent to the southbound lanes of Route #113 (right bank) showed leakage about three feet below the top of the upper stop log.

c. Appurtenant Structures

1) Wingwalls and Abutments - The concrete wingwalls and bridge abutments appear to be in good condition with only minor temperature fracture lines visible.

2) Downstream Weir and Concrete Apron - Water was flowing over the 1.5 feet twin-notched concrete weir at the upstream face of the southbound bridge span. A complete investigation was not possible. It was evident, from the flow pattern, that one of the notches was clogged. The concrete apron, downstream of the weir, seemed to be good condition as evidenced by the uniform well-defined flow pattern.

3) Miscellaneous Concrete - Undermining of the concrete lined left bank was observed between the north and southbound bridge spans. Settlement of the concrete lined right bank was also observed on the downstream face of the northbound bridge span. Cracking was noted in the south end of the southbound bridge span sidewalk.

d) Reservoir Area - The gently rising reservoir banks appear to be stable. No major erosion problems were apparent.

e) Downstream Channel - The downstream channel is wide, rock-lined and well defined. It leads directly into Silver Lake. Neither scouring nor silting were apparent.

3.2 EVALUATION

No major defects were observed during visual inspection.

SECTION 4 - OPERATIONAL PROCEDURES

According to information provided by the Department of Natural Resources and Environmental Control, the stoplogs are removed upon notification of expected flooding. There is no flood warning system in effect.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data - The Probable Maximum Flood (PMF) was determined from Probable Maximum Precipitation and standard reduction factors for geographic location and basin size. The peak discharge of the PMF is 46,800 cfs. The peak discharge for ½PMF is 23,500 cfs.

The PMF was routed through the reservoir with the starting water surface elevation at the spillway crest. The maximum water surface elevation in the reservoir resulting from PMF would be approximately 25.8 feet MSL, 11 feet above the spillway crest. Due to the small storage volume available above the spillway crest, the inflow and outflow hydrographs are virtually identical for both the PMF and ½PMF. Other percentages of PMF determined were 10%, 20%, 30%, 40%, 60%, 70% and 80%. These analyses revealed that Haven Lake is capable of passing 8% of the PMF before overtopping the highway embankment.

The time for drawdown, with all stoplogs removed and no inflow considered is approximately 30 hours (See calculations, Sheet #A-25).

b. Experience Data - No water stage recorders have been in service at the Haven Lake Dam and no high water records are available.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations - No structural deficiencies were observed during the visual inspection of the dam. However, a complete inspection was not possible since 1 to 3 inches of water was flowing over the spillway and sluiceway stop logs.

b. Design and Construction Data - The spillway is a semi-circular reinforced concrete lined structure with a maximum width at its base of 12.5 feet and a height of 7.42 feet . The inner cavity of the spillway was cleared of all unsuitable material and filled with sand and gravel (see Figure #3). Since the spillway is an integral part of the upstream face of the southbound Route #113 bridge span and the northbound bridge span is immediately downstream, the entire structure appears to be stable under flooding conditions. Four sluiceways are provided for drawdown, two on each end of the spillway. The pool elevation is controlled by seven wooden stop logs in each sluiceway. Each stop log is 6'-5" x 11¼" x 3" in size and is creosoted.

c. Operating Records - No operating records were made available.

d. Post Construction Changes - No alterations to the spillway, wingwalls, sluice gates or outlet channel are known to have been made since initial construction in 1956.

e. Seismic Stability - The dam and reservoir are above the tidal influence of Delaware River in the gently rolling land of the Atlantic Coastal Plain physiographic province in southern Delaware. Topography in the general area ranges from sea level to approximately elevation +50. Foundation materials consist of recent alluvium and silty to clayey sandy and granular unconsolidated sediments of the Plesitocene Columbia formation. Bedrock is not a consideration of foundation conditions.

This structure is located within Zone 1 of the Seismic Risk Map for the United States. Since projects located within this zone present no hazard from earthquakes when static stability conditions are satisfactory, Haven Lake Dam is considered seismically stable.

f. Evaluations - Based upon the visual inspection, the semi-circular concrete spillway structure appears to be in good condition. A detailed stability analysis of the semi-circular spillway structure and sluiceways is beyond the scope of a Phase I Report.

SECTION 7 ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety - The spillway is hydraulically inadequate to pass the PMF without overtopping the southbound roadway embankment of Route #113. The capacity of the spillway is approximately 8% of the PMF. During the period of overtopping, failure of the roadway embankment is a possibility. The Hydraulic and Hydrologic analyses reveal that the spillway can be considered to be "severely inadequate" as cited in Engineering Technical Letter No. 1110-2, January 25, 1978.

b. Adequacy of Information - Adequate information is not available to make a detailed stability analysis of the spillway. Additional information required for a more comprehensive evaluation would include construction records, boring logs and a visual inspection of the spillway during non-overflow conditions.

c. Urgency - Further investigation of the dam under no spillway overflow conditions is recommended but not considered urgent.

7.2 REMEDIAL MEASURES

a. Alternatives - In order to satisfy criteria established by the Department of the Army, Office of the Chief Engineer, remedial measures that should be considered include increasing the length of the spillway structure and providing an additional waterway to pass at least $\frac{1}{2}$ of the PMF without overtopping the embankments.

b. O&M, Maintenance and Procedures - The undermining of the concrete lining between the bridge spans on the left bank (looking downstream) should be rectified. The cavity should be filled and surface drainage routed to eliminate the problem. Surrounding soil could be sodded to eliminate erosion.

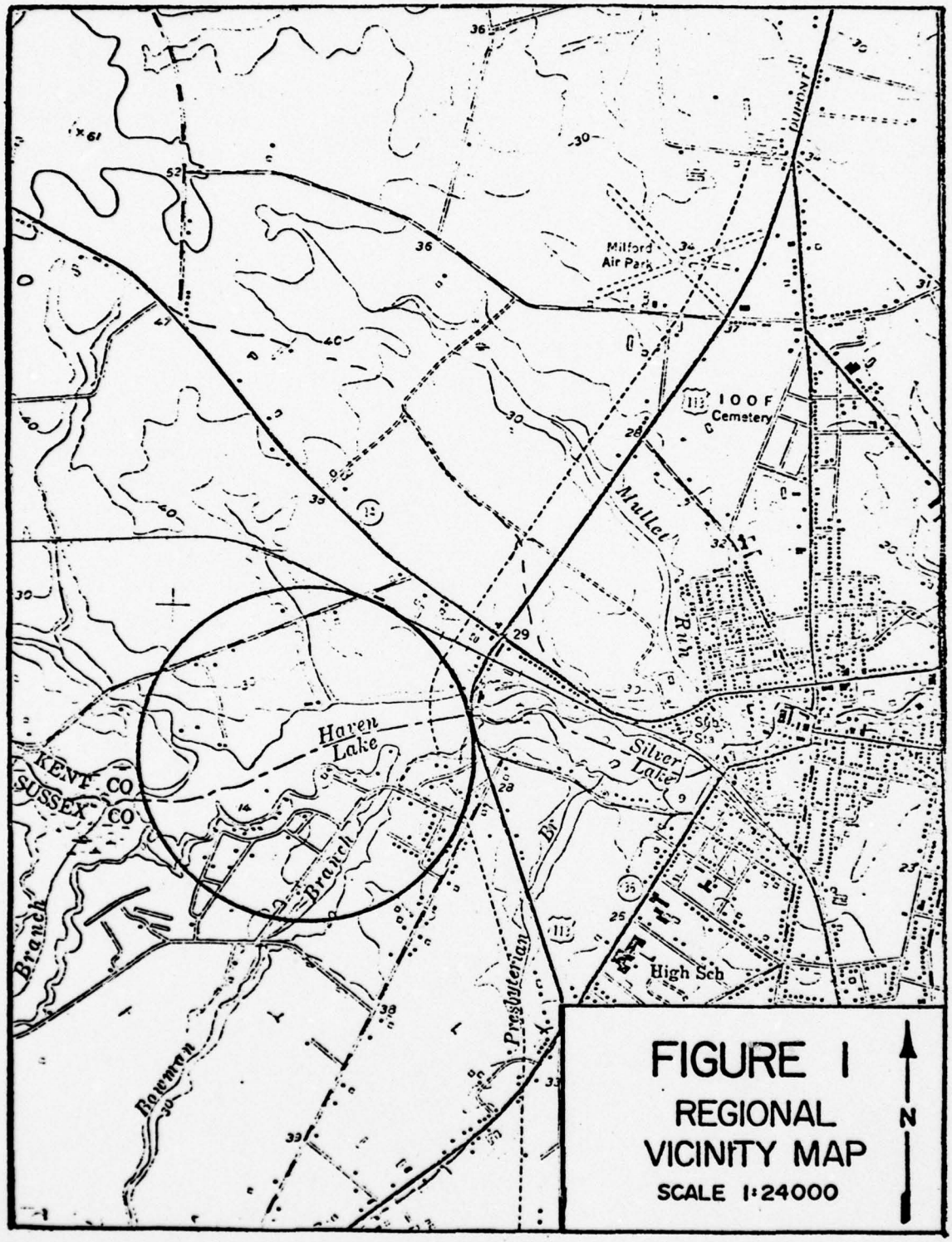
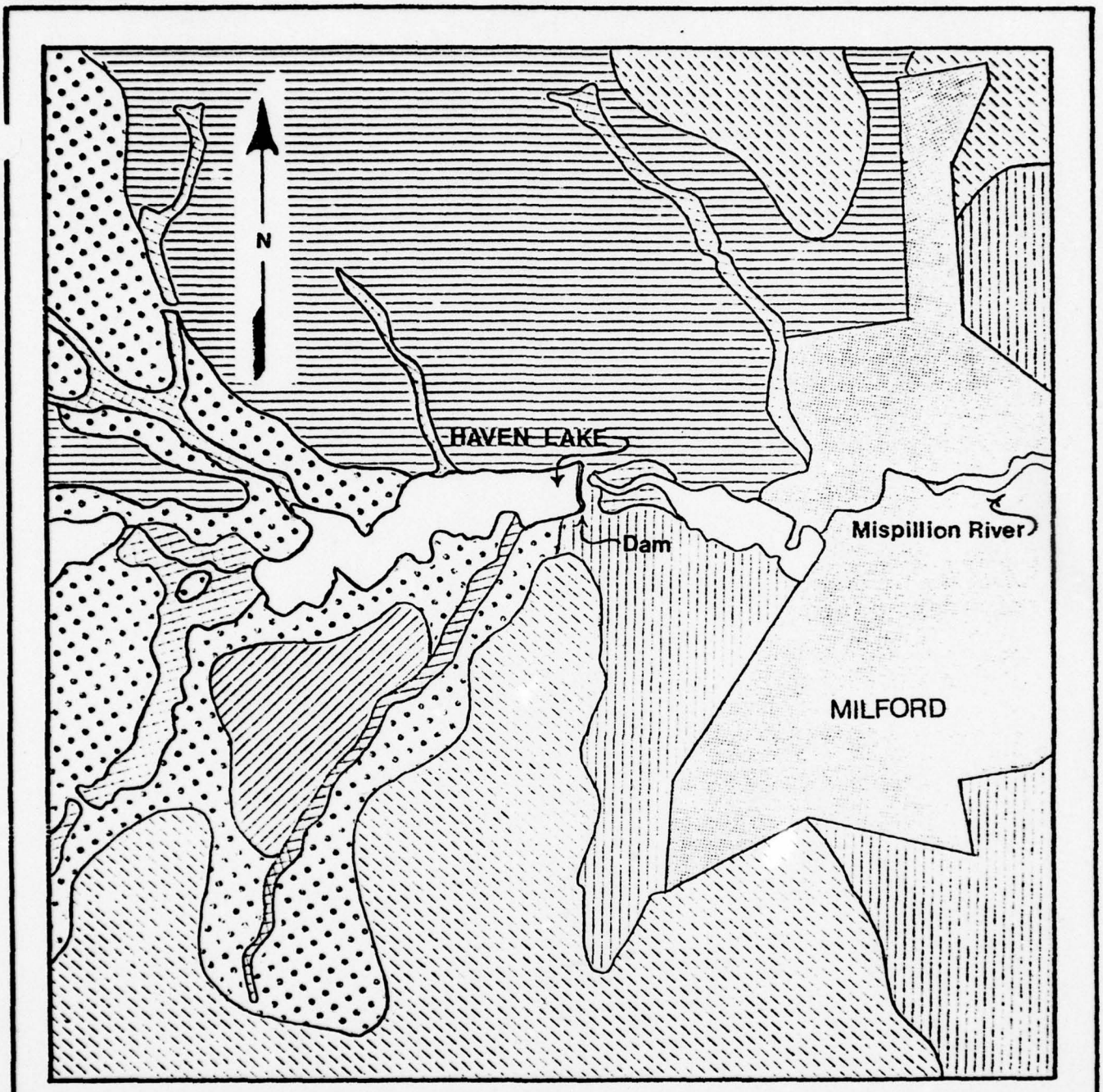


FIGURE 1
REGIONAL
VICINITY MAP
SCALE 1:24000

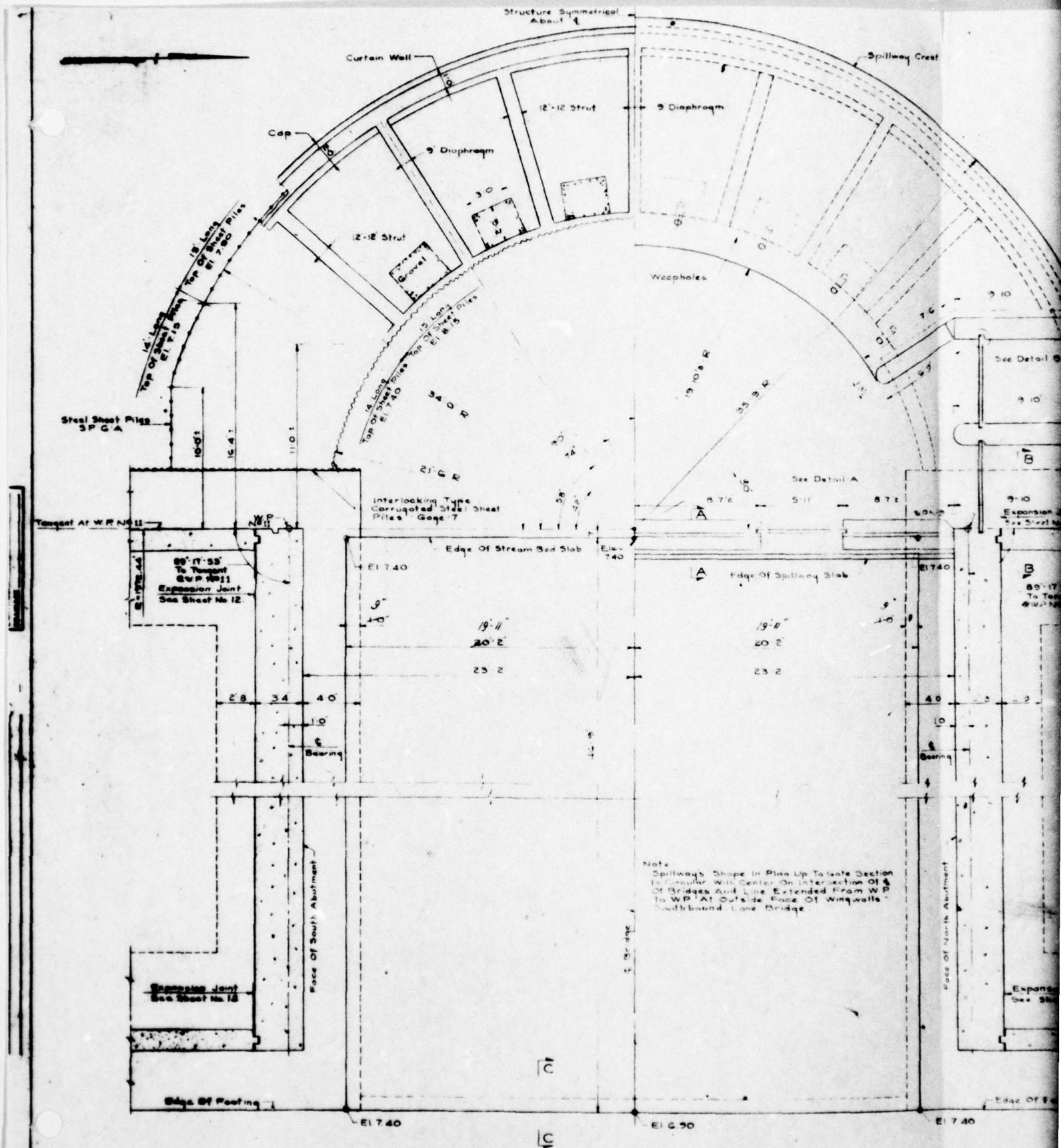


LEGEND

- AM24 - Sandy and silty soil
- AM2 - Sandy soil
- AM2/24 - Sandy soil with some silt
- AM23 - Sandy soil, poorly graded
- AR-Z - Alluvial gravel, sand, silt and clay; rich in organic material
- AM12/23 - Gravelly, sandy soil; poorly graded
- Milford, DE

FIGURE 2

GEOLOGIC MAP

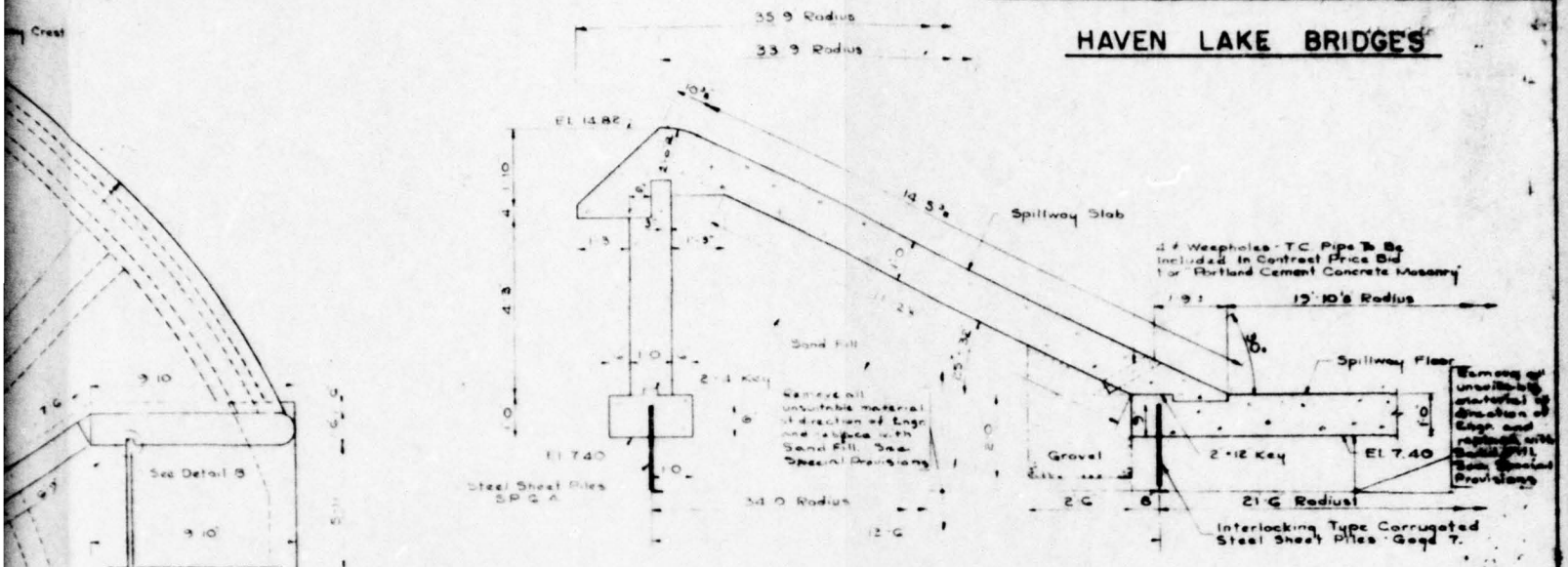


SPILLWAY PLAN & HALF SECTION

Scale: 1/4 = 1'-0"

COUNTY	CONTRACT			FED. AID PROJECT NO.			
SUSSEX	1740-1	8	RTE.	U-110 (2)		21	

HAVEN LAKE BRIDGES



TYPICAL SECTION THRU SPILLWAY

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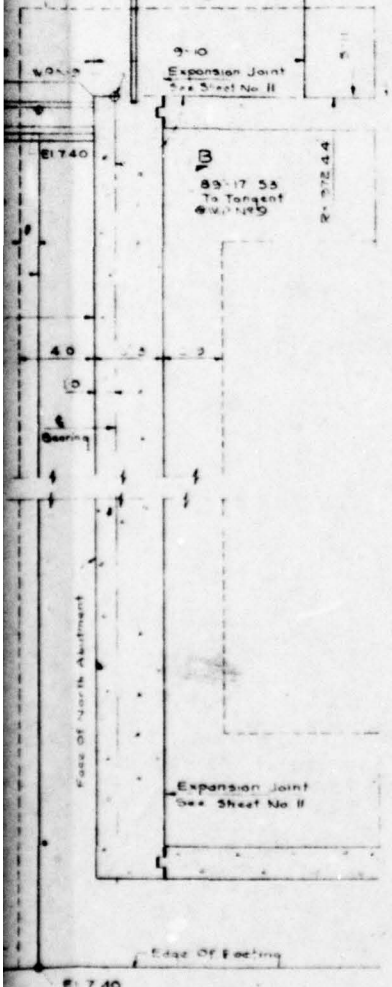

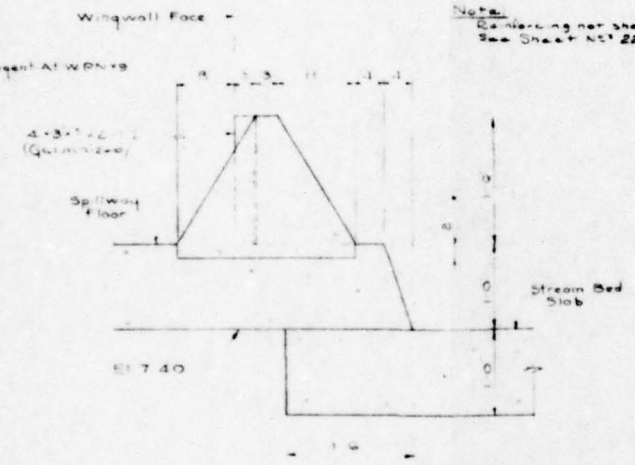

SECTION AA

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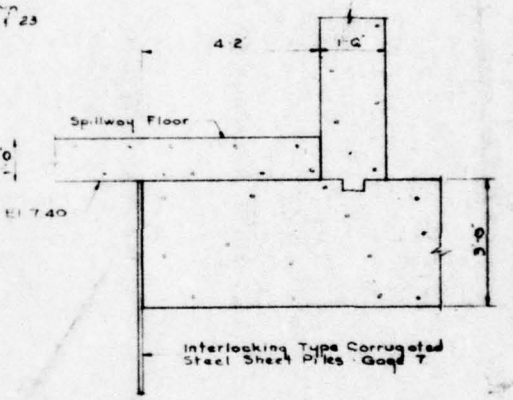

SECTION BB

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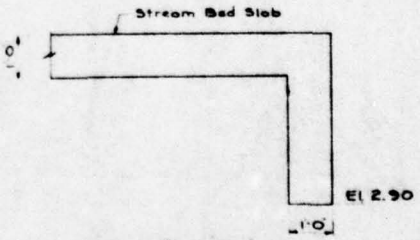
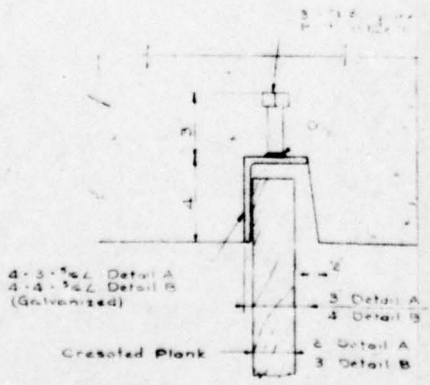


SECTION CC

Scale 1"=1'0



DETAIL A & B

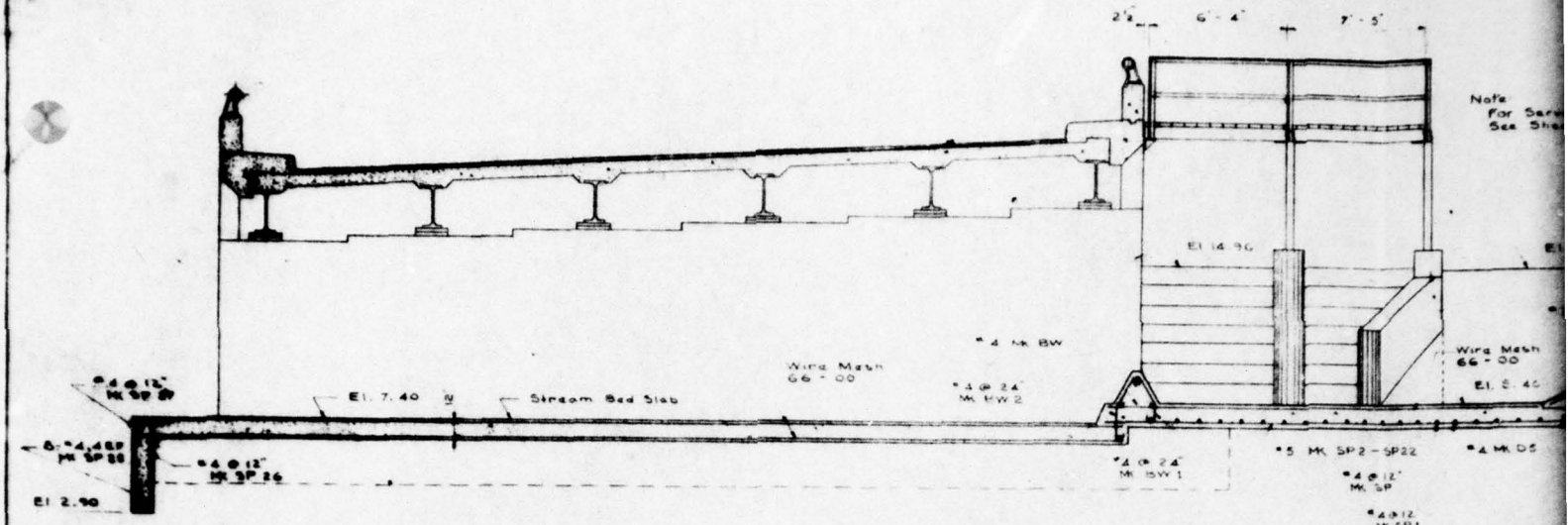
Scale 3"=1'0

DELAWARE
STATE HIGHWAY DEPARTMENT

U.S. ROUTE 113
MILFORD BY-PASS TO WALNUT STREET EXTENSION
DAM AT HAVEN LAKE
SPILLWAY PLAN AND SECTIONS

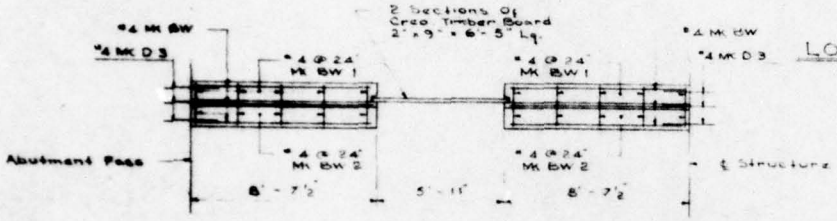
D R.L.W.	SCALE AS SHOWN	APPROVED
T		
C G.L.W.		

FIGURE 3



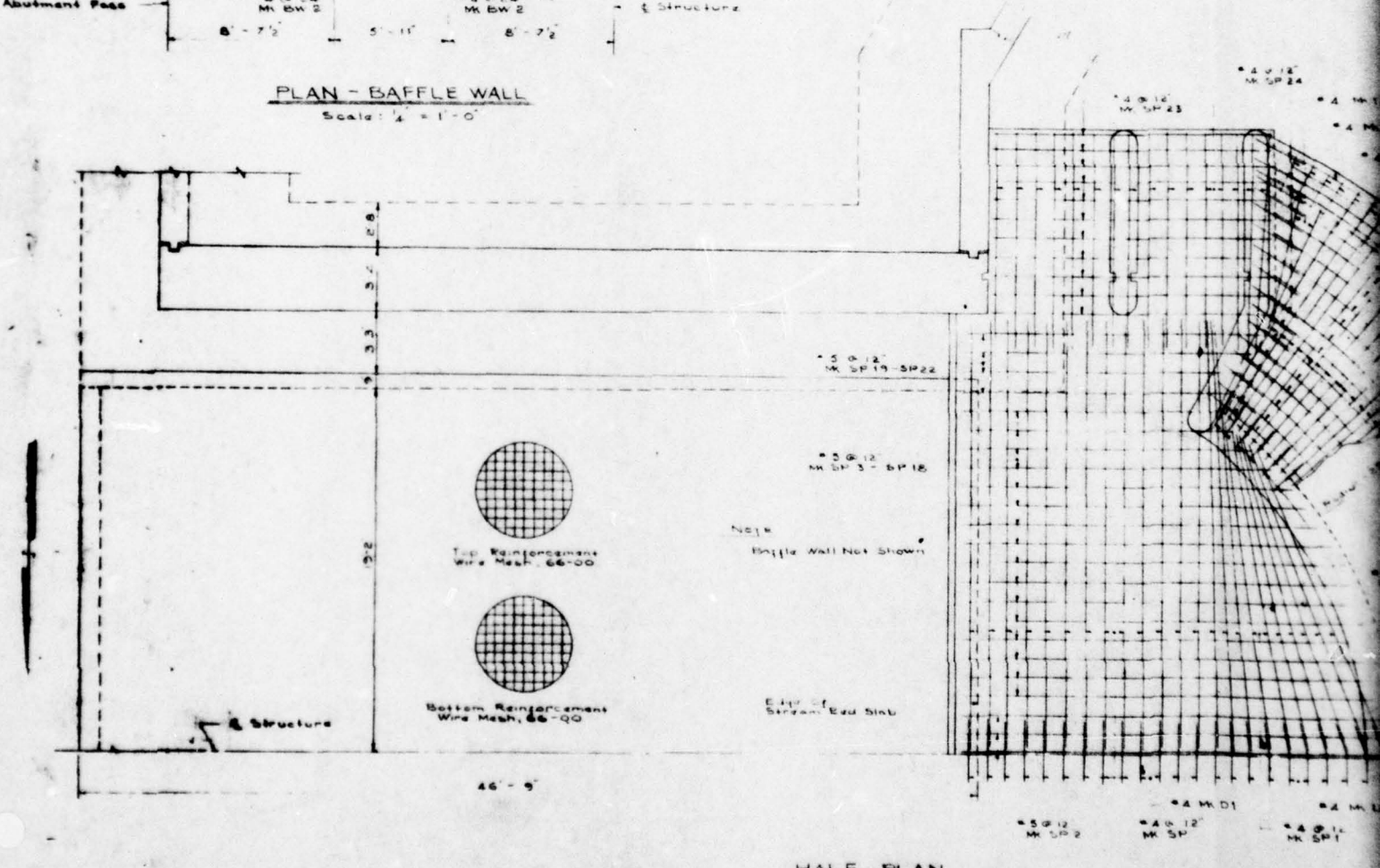
LONGITUDINAL SECTION

Scale : 1/4 = 1' - 0"



PLAN - BAFFLE WALL

Scale : 1/4 = 1' - 0"

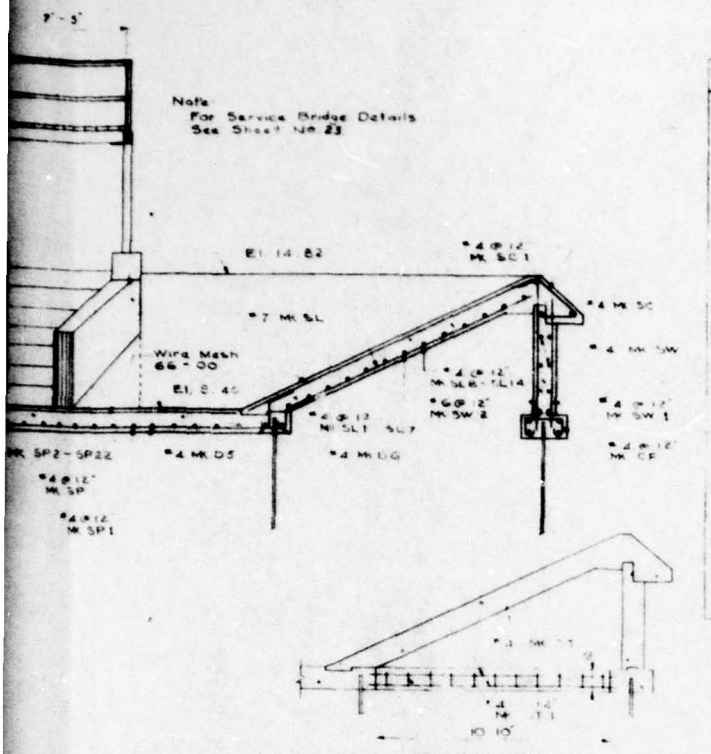


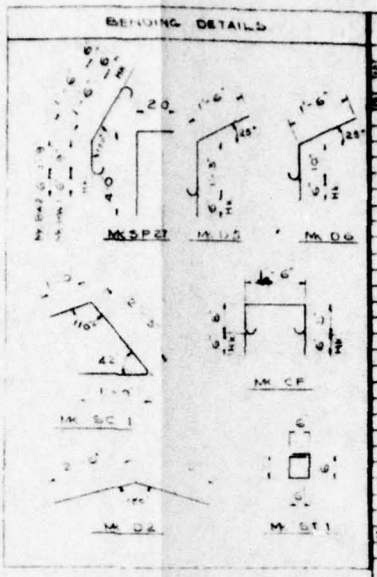
HALF PLAN

Scale : 1/4 = 1' - 0"

COUNTY	CONTRACT	A.A.R. No.	STATE	FED. AID PROJECT No.	FISCAL YEAR	SHEET No.	TOTAL SHEETS
SUSSEX	1740-1	8	DEL.	U-116(8)		22	39

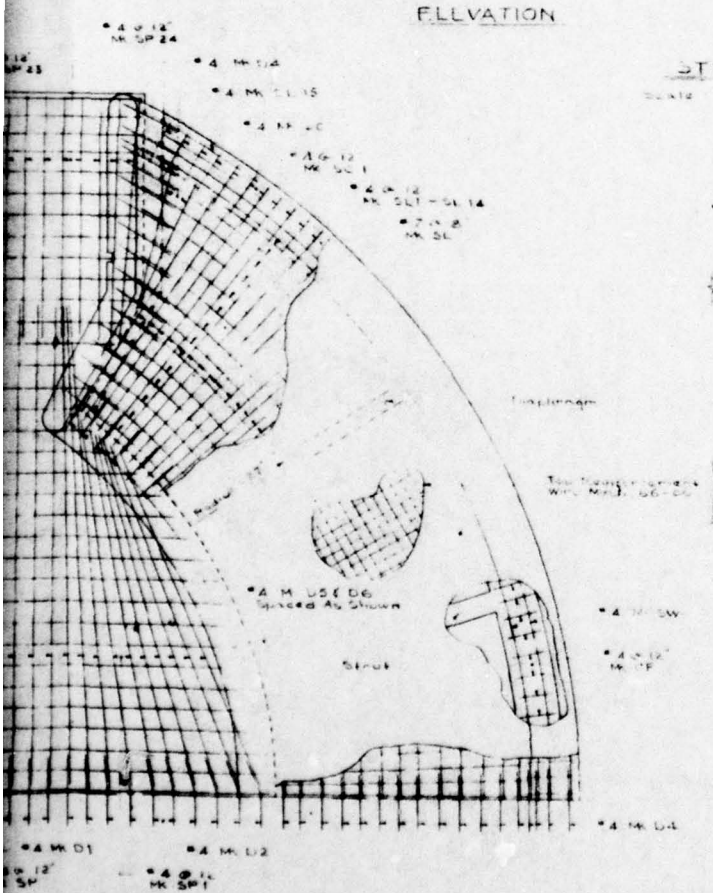
HAVEN LAKE BRIDGES





LOCATION	STRAIGHT BARS					BENT BARS				
	Wt	No.	Size	Length	Mk	No.	Size	Length	Mk	Wt
Struct. Bed Slab			# Wire Mesh, 66-00							
Spillway Floor	498	38	#4	35'-0"	SP					
	199	14	#4	17'-0"	SP1					
	144	6	#5	23'-0"	SP2					
	47	2	#5	22'-9"	SP3					
	47	2	#5	22'-6"	SP4					
	46	2	#5	22'-3"	SP5					
	46	2	#5	22'-0"	SP6					
	45	2	#5	21'-9"	SP7					
	45	2	#5	21'-6"	SP8					
	44	2	#5	21'-3"	SP9					
	43	2	#5	20'-6"	SP10					
	42	2	#5	20'-3"	SP11					
	40	2	#5	19'-3"	SP12					
	39	2	#5	18'-6"	SP13					
	37	2	#5	17'-9"	SP14					
	35	2	#5	16'-9"	SP15					
	33	2	#5	15'-9"	SP16					
	30	2	#5	14'-6"	SP17					
	28	2	#5	13'-6"	SP18					
	30	2	#5	14'-6"	SP19					
	31	2	#5	15'-0"	SP20					
	32	2	#5	15'-6"	SP21					
	33	2	#5	16'-0"	SP22					
	220	22	#4	10'-0"	SP23					
	384	32	#8	11'-6"	SP24					
	35	15	#4	4'-0"	D1	10	#4	5'-6"	D5	57
	1148	Wire Mesh, 66-00								
Struct. Bed Toe	214	16	#4	20'-0"	SP25					
	123	37	#4	4'-0"	SP26	37	#4	6'-6"	SP27	384
	67	12	#4	8'-4"	SW	20	#4	5'-5"	SW1	69
	15	9	#4	2'-6"	D3	20	#4	6'-8"	SW2	57
Spillway Slab	2548	85	#7	15'-6"	SL	42	#4	5'-8"	D8	91
	29	2	#4	21'-6"	SL1	42	#4	2'-10"	D6	79
	30	2	#4	22'-6"	SL2					
	31	2	#4	23'-6"	SL3					
	33	2	#4	24'-6"	SL4					
	34	2	#4	25'-6"	SL5					
	35	2	#4	26'-6"	SL6					
	37	2	#4	27'-6"	SL7					
	39	2	#4	28'-6"	SL8					
	43	4	#4	16'-0"	SL9					
	45	4	#4	16'-9"	SL10					
	47	4	#4	17'-6"	SL11					
	49	4	#4	18'-3"	SL12					
	51	4	#4	19'-0"	SL13					
	53	4	#4	19'-9"	SL14					
	16	4	#4	6'-0"	SL15					
	84	42	#4	3'-0"	D4					
	888	Wire Mesh, 66-00								
Spillway Crest	56	4	#4	21'-6"	SC	80	#4	3'-0"	SC1	237
	6	3	#4	3'-0"	D6					
Spillway Curtain Wall	481	36	#4	20'-0"	SW					
	334	80	#4	6'-3"	SW1					
	611	80	#4	6'-5"	SW2					
	54	27	#4	3'-0"	D4					
Cap	214	16	#4	20'-0"	SP	80	#4	3'-10"	CF	205
Diaphragms	166	24	#2	10'-6"	DF					
	27	18	#4	2'-3"	DF1					
	98	48	#2	3'-6"	DF2					
	80	48	#4	2'-6"	D3					
Struts	130	16	#4	12'-2"	ST	44	#4	2'-6"	ST1	73
Total Weights	8,086#									1026#

Total (Wire Mesh) = 5,757#



Notes

1. Struts & Diaphragms, For Locations See Sheet No 21.

DELAWARE
STATE HIGHWAY DEPARTMENT

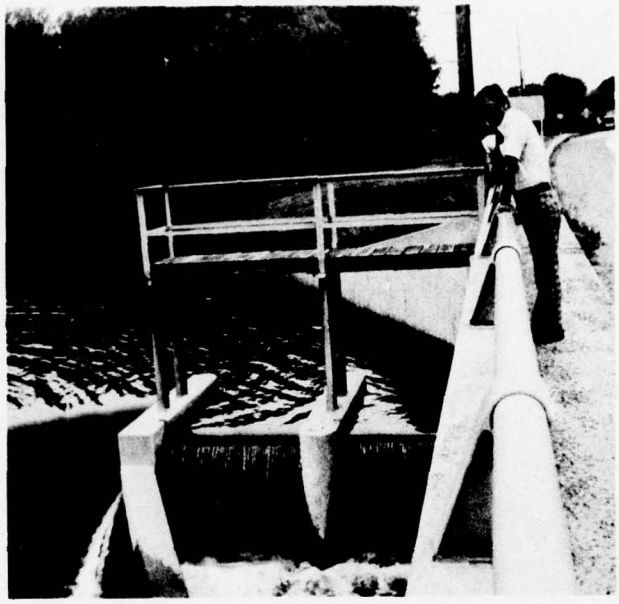
U.S. ROUTE 113
MILFORD BY-PASS TO WALNUT STREET EXTENSION
DAM AT HAVEN LAKE
REINFORCING DETAILS - SPILLWAY

D C.S.	SCALE AS SHOWN	APPROVED
T		
C G.L.W.		

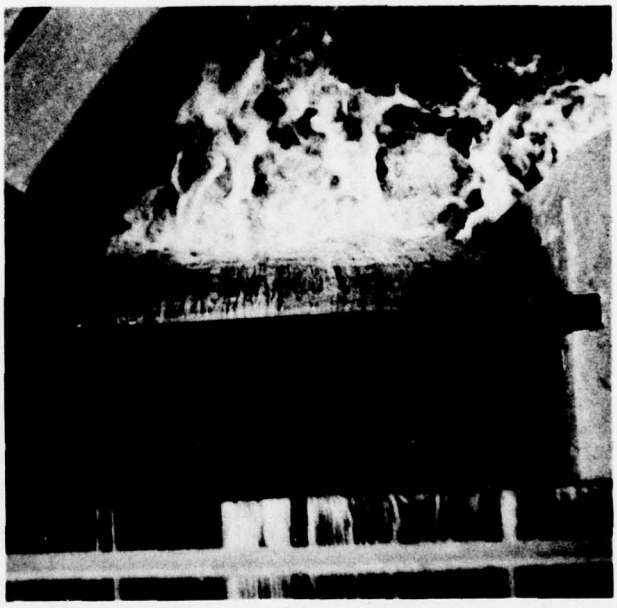
FIGURE 4

APPENDIX

PHOTOGRAPHS



SLUICEWAY AND ACCESS WALKWAYS



SLUICEWAY WITH STOP LOGS IN PLACE

UNDERMINING OF CONCRETE LINING BETWEEN BRIDGE SPANS ON LEFT BANK

CONCRETE DETERIORATION OF SIDEWALK ON SOUTHBOUND BRIDGE SPAN

FIELD INSPECTION REPORT

Check List
Visual Inspection
Phase 1

Name Dam Haven Lake Dam County Kent County Sussex County State Delaware Coordinators Mr.Krishna Pate

Date(s) Inspection 5/24/78 Weather Overcast Temperature 65°

Pool Elevation at Time of Inspection 15.00 M.S.L. Tailwater at Time of Inspection 8.4 M.S.L.

A-5

Inspection Personnel:

Mr. George C. Elias

Mr. Frank E. Falcone

Mr. Richard E. Horvath

Mr. Frank E. Falcone Recorder

Mr. Krishna Patel - Division Engineer
State of Delaware
Division of Soil and Water Conservation

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBERSVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Minor temperature cracking along wing walls and construction joints.	None.
STRUCTURAL CRACKING	None apparent in abutments or wing walls, spillway or apron. Not observed since overflow was occurring.	Spillway should be examined for concrete cracking under no overflow conditions.
VERTICAL AND HORIZONTAL ALIGNMENT	Downstream right bridge abutment shows approximately 3" vertical settlement.	No improvement recommended.
MONOLITH JOINTS	Very good condition, no spalling or major cracks. Spillway or apron not observed due to overflow.	Spillway should be examined under no overflow conditions.
CONSTRUCTION JOINTS	Very good condition. Spillway or apron not observed due to overflow.	Same as above.

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Gentle slopes, no indication of sliding	None.
SEDIMENTATION	No apparent silting problems.	None.

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEEPAGE OR LEAKAGE	No seepage observed through the spillway section. However, leakage was occurring through the stoplogs in the right bank sluiceway (looking downstream) immediately adjacent to the bridge abutment.	Reservoir pool elevation should be lowered below spillway crest in the Fall to allow for inspection.
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Abutments and wing walls in very good condition with the exception of minor concrete temperature cracking.	None.
DRAINS	4" weep holes shown on plans, not observed in field inspection (See Figure #3).	Drawdown below spillway crest will allow for inspection of weep holes.
WATER PASSAGES	None.	None.
FOUNDATION	Unobserved.	None.

ITEM	REMARKS
DESIGN REPORTS	None available.
GEOLOGY REPORTS	None available.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None available.
POST-CONSTRUCTION SURVEYS OF DAM	No records available.
BORROW SOURCES.	No records available.

ITEM	REMARKS
MONITORING SYSTEMS	None.
MODIFICATIONS	None.
HIGH POOL RECORDS	None available.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None available.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None.
MAINTENANCE OPERATION RECORDS	None available.

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	The channel downstream of the concrete apron is wide and unobstructed. Stream bed is well-defined and lined with large rock and gravel.	Downstream channel immediately flows into Silver Lake.
SLOPES	Gentle, tree-lined, well defined.	None.
APPROXIMATE NO. OF HOMES AND POPULATION	Downstream channel flows immediately into Silver Lake, no homes or population in danger.	No.

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Very good condition, no structural damage visible, overflow occurring at approximately 0.2 feet depth.	Should be inspected with reservoir pool elevation lowered below spillway crest.
APPROACH CHANNEL	None.	None.
DISCHARGE CHANNEL	Excellent condition, one of the two notches in the 1.5 feet downstream weir seemed to be clogged at the time of inspection.	Should be inspected during times of no or very low flow.
BRIDGE AND PIERS	Two steel observation piers extend out above stop logs. These piers have wooden decks and are in very good condition.	Frequent inspections of the wooden deck are required to insure safety.

ITEM	REMARKS
SPILLWAY PLAN	
SECTIONS	Available in As Built Drawings, see Figure #3.
DETAILS	Available in As Built Drawings, See Figures #3 and #4.
OPERATING EQUIPMENT PLANS & DETAILS	Operating equipment consists of removable creosoted wooden stop logs in each of four sluice ways. Plans and details are available in the As Built Drawings dated April 27, 1961.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	As built drawings dated April 27, 1961 available and in excellent condition.
REGIONAL VICINITY MAP	U.S. Geological Survey Map used.
CONSTRUCTION HISTORY	None available.
TYPICAL SECTIONS OF DAM	See Figures #3 and #4.
HYDROLOGIC/HYDRAULIC DATA	Information provided by the U.S. Army Engineer District, Philadelphia, PA.
OUTLETS - PLAN - DETAILS -CONSTRAINTS -DISCHARGE RATINGS	Complete profile provided in drawings, see Figure #4.
RAINFALL/RESERVOIR RECORDS	Rainfall data obtained from Technical Paper #40. No reservoir records available.

HYDRAULIC & HYDROLOGIC
CALCULATIONS

O'BRIEN&GERE ENGINEERS

SUBJECT	SHEET	BY	DATE	JOB NO
HAVEN LAKE DAM	1	R.E.H	5/29/78	1800 001 19

PMF COMPS

Drainage Area = 30 sq miles — From USGS Quad Sheet 7½ MIN series

PMP - 6 hr duration, 10 sq miles, zone 6

= 28"

- Isohyetal "fit" reduction factor = 17.5 %
- Depth - Area - Duration adjustment = 91 %

adjusted PMP = [28" - .175(28")] .91 = 21"

O'BRIEN & GERE ENGINEERS

SUBJECT	SHEET	BY	DATE	JOB NO
HAVSN LAKE DAM	2	RE L	5/29/79	1800 00 12

TIME (Hrs)	% 6 hr PMP	Σ 6 Hr PMP	Incr PMP	
.5	.30	6.3	6.3	①
1.0	.50	10.5	4.2	②
1.5	.58	12.2	1.7	④
2.0	.65	13.7	1.5	⑧
2.5	.70	14.7	1.0	⑦
3.0	.75	15.8	1.1	⑤
3.5	.80	16.8	1.0	⑧
4.0	.85	17.9	1.1	⑥
4.5	.88	18.5	.6	⑫
5.0	.93	19.5	1.0	⑨
5.5	.96	20.2	.7	⑪
6.0	1.00	21.0	.8	⑩

O'BRIEN & GERE ENGINEERS

SUBJECT	SHEET	BY	DATE	JOB NO
HAVEN LAKE DAM	3	REH	5/29/78	1800001 199

	RAINFALL		RUNOFF		LOSSES	
	Σ	INC	Σ	INC	Σ	INC
5	.6	.6	0	0	.6	.6
10	1.3	.7	0	0	1.3	.7
15	2.1	.8	.3	.3	1.8	.5
20	3.2	1.1	.8	.5	2.4	.6
25	4.3	1.1	1.5	.7	2.8	.4
30	5.8	1.5	2.6	1.1	3.2	.4
35	10.0	4.2	6.2	3.6	3.8	.6
40	16.3	6.3	12.1	5.9	4.2	.4
45	18.0	1.7	13.7	1.6	4.3	.1
50	19.0	1.0	14.7	.9*	—	.1*
55	20.0	1.0	15.6	.9	—	.1
60	21.0	1.0	16.6	.9*	—	.1*

* Assume minimum loss rate
= .2"/hr

CN = 70

SNYDER'S PARAMETERS

$C_t = .9$ and $640 C_p = 310$ - Provided by the Dept of the Army, Phil Dist., Corps of Engrs

$L = 8.7$ miles $L_{CA} = 4.35$ miles

$T_p = C_t(L L_{CA})^{.3} = 2.68$

$C_p = .48$

Division of O'Brien & Gere Engineers, Inc.
PHILADELPHIA, PA

SHEET NO. 1 OF _____

DATE 7/17/78

NAME OF CLIENT _____

COMP. BY FEF

PROJECT HAVEN LAKE DAM

CHECKED BY DBC

STAGE/DISCHARGE RELATIONSHIP

① WEIR FLOW FROM EL. 14.82 TO LOW CHORD EL. 17.32 $Q = CLH^{3/2}$, $C = 3.2$

② PRESSURE FLOW FROM EL. 17.3 TO MINIMUM ROADWAY EL. 19.2

③ WEIR FLOW OVER ROADWAY FROM EL. 19.2 TO APPROX. 26.1. $Q = CLH^{3/2}$, $C = 3.0$ + PRESSURE FLOW.

1. WEIR FLOW OVER SPILLWAY — $L = 110'$, $C = 3.2$, $CL = 352$ | $L = 24'$, $C = 3.2$, $CL = 76.8'$

SPILLWAY			STOPLOGS			TOT. SPILL. Q
ELEVATION	HEAD	DISCHARGE	ELEVATION	HEAD	DISCHARGE	
14.82	0	0	14.96	0	0	0
15.32	0.5	123.2	15.32	0.36	16.6	139.8
15.82	1.0	352.0	15.82	0.86	61.3	413.3
16.32	1.5	647.7	16.32	1.36	121.8	769.5
16.82	2.0	996.2	16.82	1.86	194.8	1191.0
17.32	2.5	1390.4	17.32	2.36	278.4	1668.8

2. PRESSURE FLOW THROUGH OPENING (TAILWATER EL. ASSUMED @ 17.32)

$\Delta H = (1 + Ke + 29N^2L/R^{1.33}) V^2/2g$

$\Delta H = 1.559 V^2/2g$

$\Delta H = .0242 V^2$

$V = (\Delta H/.0242)^{1/2}$

$R = A/WP = (7.5 \times 40.3)/(2 \times 7.5) + (2 \times 40.3)$

$R = 302.25/95.6 = 3.16$, $R^{1.33} = 4.62$

$N = .015$, $L = 42$ Ft.

$Ke = .05$

$29N^2L = 29 \times (.015)^2 \times 42 = .274$

$Q = AV$

$A = 302.25$

PRESSURE FLOW

ELEVATION	ΔH	V	Q
17.32	0	0	0
17.82	0.5	4.55	1375.2
18.32	1.0	6.43	1943.5
18.82	1.5	7.87	2378.7
19.32	2.0	9.09	2747.5
19.82	2.5	10.16	3070.9

PRESSURE FLOW CONTINUED

ELEVATION	ΔH	V	Q
20.32	3.0	11.13	3364.0
20.82	3.5	12.03	3636.1
21.32	4.0	12.86	3886.9
21.82	4.5	13.64	4122.7
22.32	5.0	14.37	4343.3
23.32	6.0	15.75	4760.4
24.32	7.0	17.01	5141.3
25.32	8.0	18.18	5494.9
26.32	9.0	19.28	5828.8

3. WEIR FLOW OVER ROADWAY $C = 3.0$ $Q = CLH^{3/2}$
$L = 809$, $CL = 2427$

ELEVATION	HEAD	DISCHARGE
19.20	0	0
19.32	0.12	100.9
19.82	0.62	1184.8
20.32	1.12	2876.7
20.82	1.62	5004.3
21.32	2.12	7491.6
21.82	2.62	10292.5
22.32	3.12	13375.2
23.32	4.12	20296.2
24.32	5.12	28117.4
25.32	6.12	36744.9
26.32	7.12	46109.4

JUSTIN & COURTNEY, INC.
Division of O'Brien & Gere Engineers, Inc.
PHILADELPHIA, PA

SHEET NO. 3 OF _____
DATE 7/17/76
COMP. BY F&F
CHECKED BY DBC

NAME OF CLIENT _____
PROJECT Haven Lake Dam

Total Discharge Determination

Elevation	Spillway Q.	Pressure Q.	Roadway Q.	Total Q	
14.82	0			0	
15.32	139.8			139.8	
15.82	413.3			413.3	
16.32	769.5			769.5	
16.82	1191.0			1191.0	
17.32	1668.8			1668.8	
17.82		1375.2		1375.2	CONTROL CHANGES
18.32		1943.5		1943.5	
18.82		2378.7		2378.7	
19.32		2747.5	100.9	2848.4	
19.82		3040.9	1184.8	4225.7	
20.32		3364.0	2876.7	6240.7	
20.82		3636.1	5004.3	8640.4	
21.32		3886.9	7491.6	11378.9	
21.82		4122.7	10292.5	14415.2	
22.32		4343.3	13375.2	17718.5	
23.32		4760.4	20296.2	25056.6	
24.32		5141.3	28117.4	33258.7	
25.32		5494.9	36744.9	42239.8	
26.32		5828.8	46109.4	51938.2	

Division of O'Brien & Gere Engineers, Inc.
PHILADELPHIA, PA

SHEET NO. 4 OF

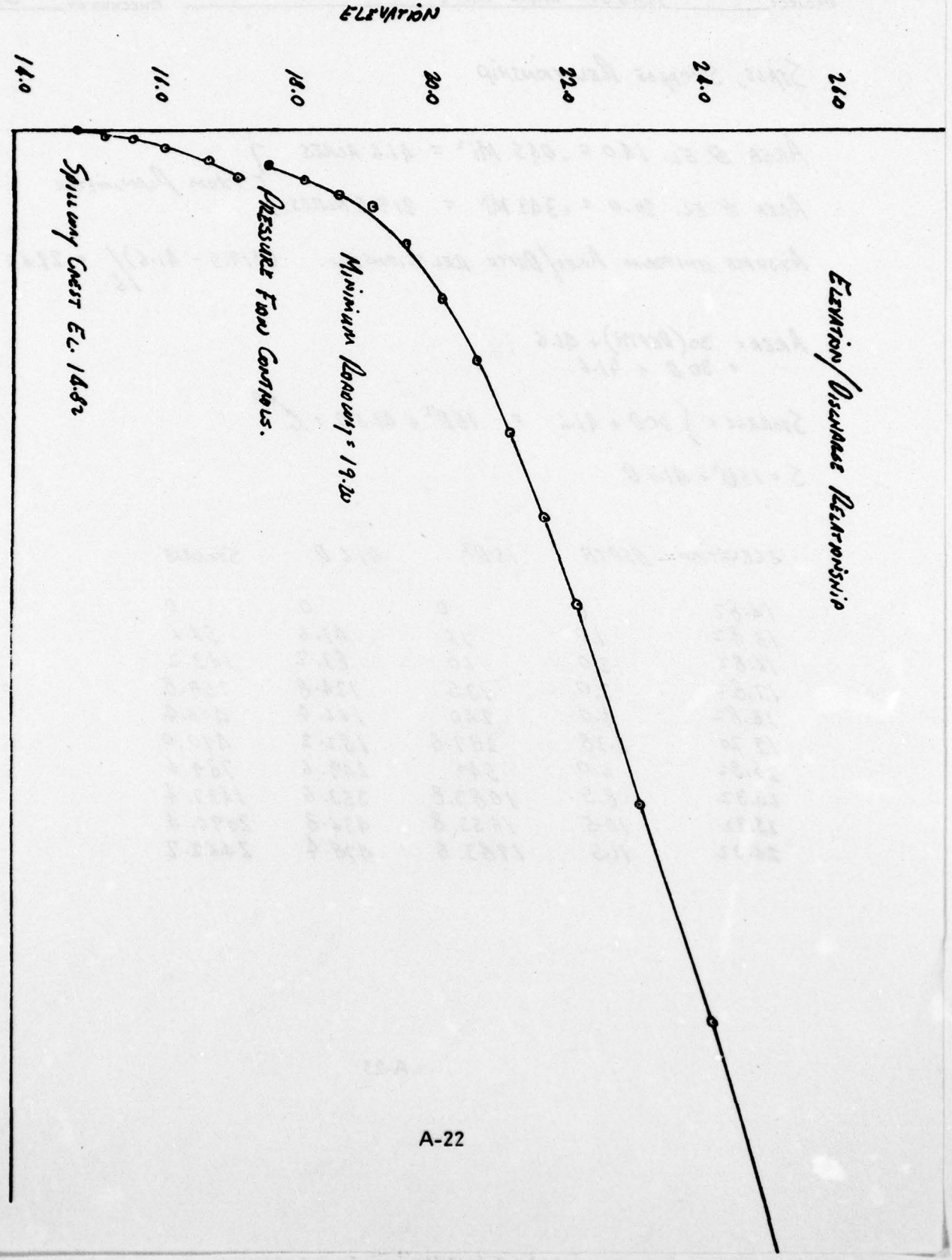
DATE 7/17/78

NAME OF CLIENT

COMP. BY FEF

PROJECT HAVEN LAKE DAM

CHECKED BY DBC



STAGE, STORAGE RELATIONSHIP

AREA @ EL. 14.0 = .065 Mi^2 = 41.6 ACRES
AREA @ EL. 20.0 = .343 Mi^2 = 219.5 ACRES. } FROM PLANIMETER

ASSUME UNIFORM AREA/DEPTH RELATIONSHIP. $(219.5 - 41.6)/6 = 29.65 \cong 30$ ACRE

AREA = 30(DEPTH) + 41.6
= 30D + 41.6

STORAGE = $\int 30D + 41.6 = 15D^2 + 41.6D + C$ (C = 0)

$S = 15D^2 + 41.6D$

ELEVATION	DEPTH	$15D^2$	41.6 D	STORAGE
14.82	0	0	0	0
15.82	1.0	15	41.6	56.6
16.82	2.0	60	83.2	143.2
17.82	3.0	135	124.8	259.8
18.82	4.0	240	166.4	406.4
19.20	4.38	287.8	182.2	470.0
20.82	6.0	540	249.6	789.6
23.32	8.5	1083.8	353.6	1437.4
25.32	10.5	1653.8	436.8	2090.6
26.32	11.5	1983.8	478.4	2462.2

Division of O'Brien & Gere Engineers, Inc.
PHILADELPHIA, PA

SHEET NO. 6 OF _____

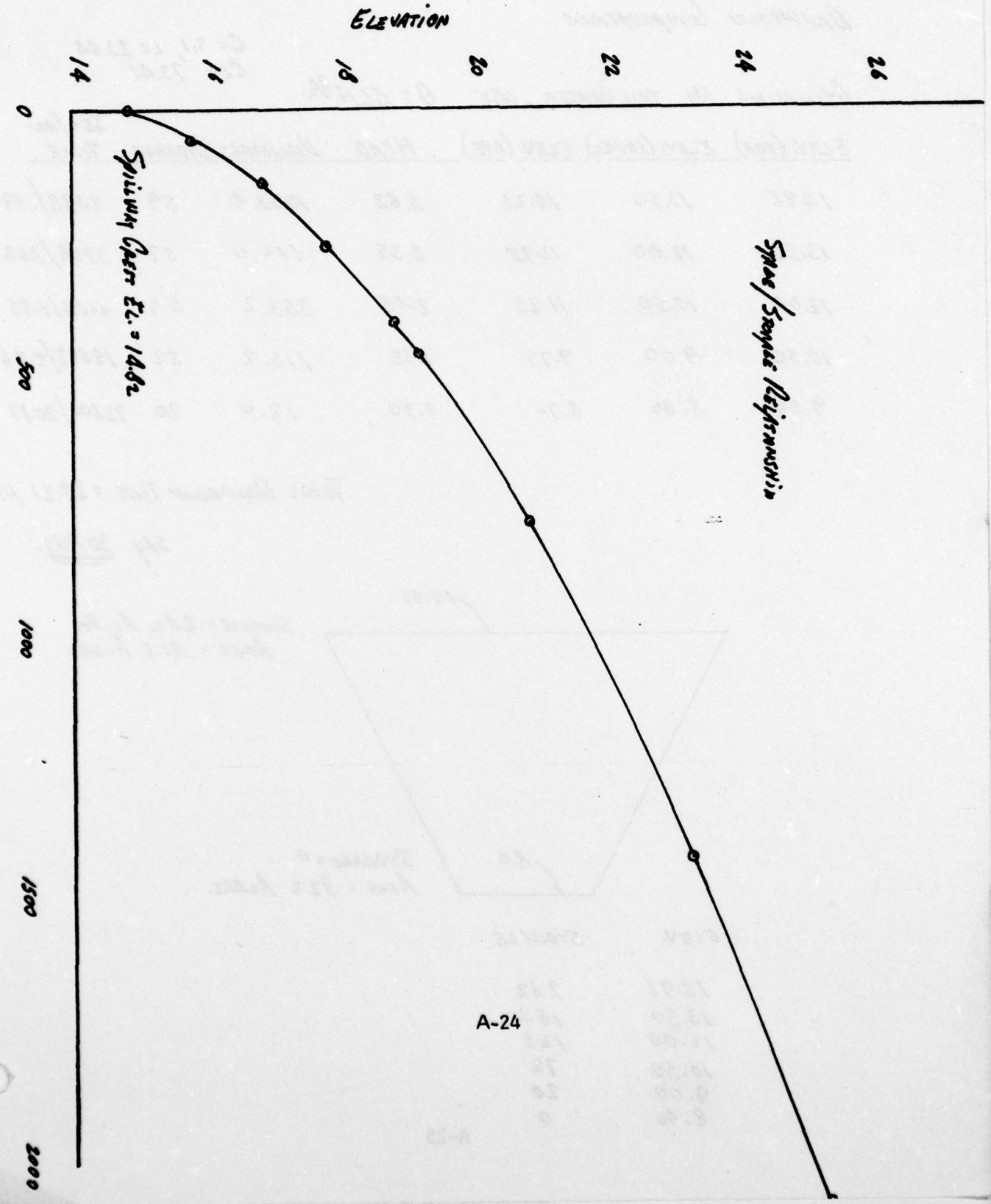
DATE 7/17/78

NAME OF CLIENT _____

COMP. BY FF

PROJECT Haven Lake Dam.

CHECKED BY DBC



Division of O'Brien & Gere Engineers, Inc.
PHILADELPHIA, PA

SHEET NO. _____ OF _____

DATE 7/7/78

NAME OF CLIENT _____

COMP. BY FES

PROJECT HAVEN LAKE DAM

CHECKED BY DBC

DRAWDOWN COMPUTATIONS

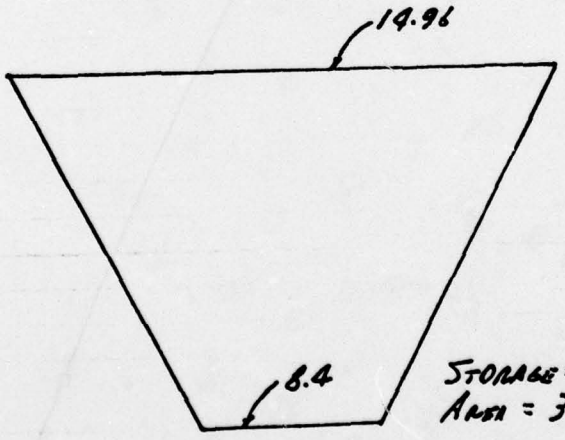
C = 3.1, L = 23.68
CL = 73.41

ASSUMING NO TAILWATER, USE $Q = CLH^{3/2}$

ELEV. (TOP)	ELEV. (LOWER)	ELEV. (AVE.)	HEAD	DISCHARGE	STORAGE	SEC/HR. TIME
14.96	13.50	14.23	5.83	1033.4	59	2488/.69
13.50	12.00	12.75	4.35	666.0	57	3728/1.04
12.00	10.50	11.25	2.85	353.2	54	6664/1.85
10.50	9.00	9.75	1.35	115.2	52	19663/5.46
9.00	8.40	8.70	0.30	12.0	20	72600/20.17

TOTAL DRAWDOWN TIME = 29.21 HRS.

SAY 30 HRS.



STORAGE = 242 AC. FT.
AREA = 41.6 ACRES

STORAGE = 0
AREA = 32.2 ACRES.

ELEV.	STORAGE
14.96	242
13.50	183
12.00	126
10.50	72
9.00	20
8.40	0

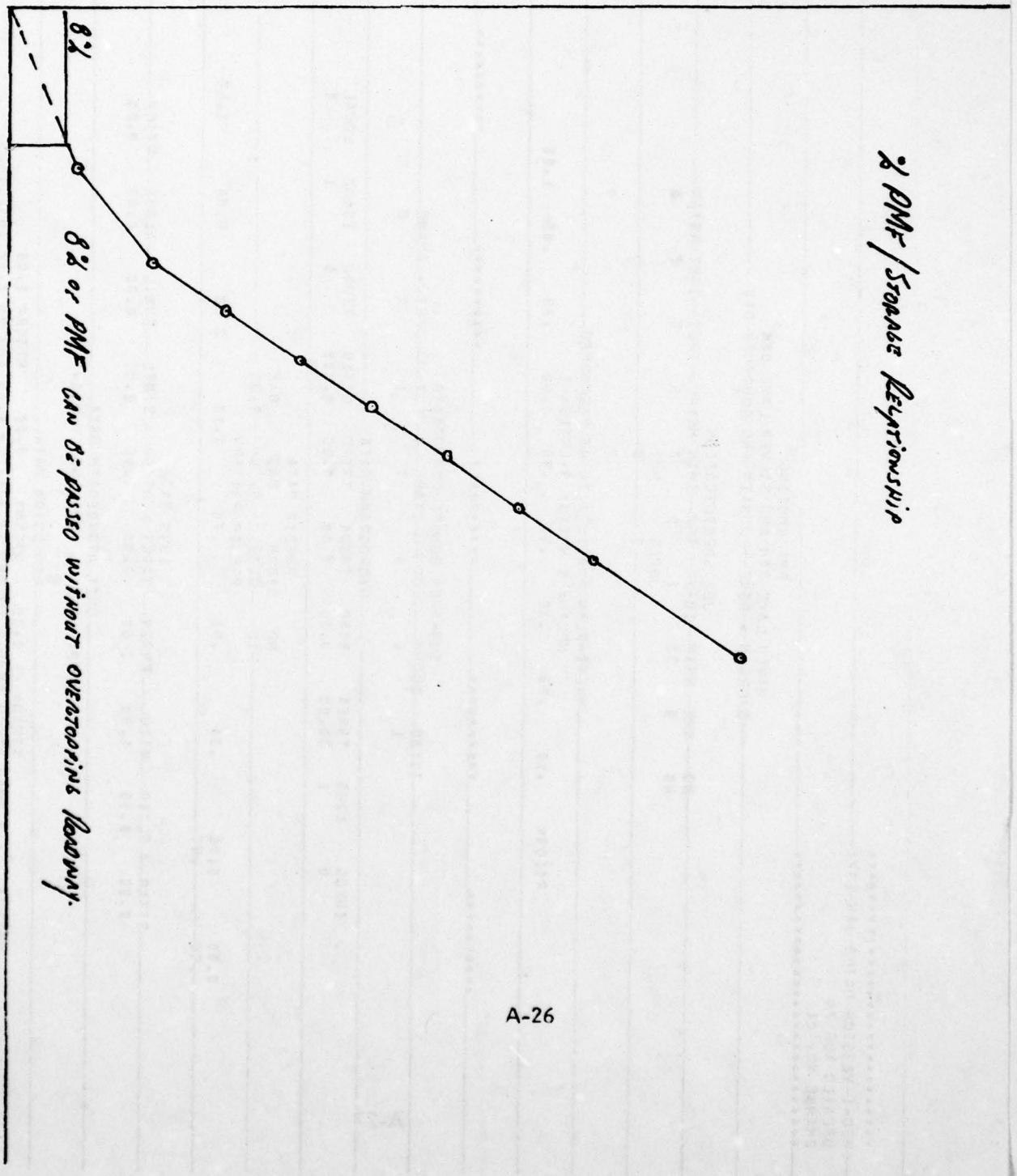
JUSTIN & COURTNEY, INC.
Division of O'Brien & Gere Engineers, Inc.
PHILADELPHIA, PA

SHEET NO. 8 OF _____
DATE 7/17/78
COMP. BY FBF
CHECKED BY DBC

NAME OF CLIENT _____

PROJECT HAVEN LAKE DAM

% PMF / STORAGE RELATIONSHIP



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**********
HEC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01
**********

                                    PMF ROUTING
                          HAVEN LAKE DAM AND SILVER LAKE DAM
                              O'BRIEN-GERE-JUSTIN-AND-COURTNEY-DIV

                                  JOB SPECIFICATION
      NO   NHR  NMIN  IDAY  IHR  IMIN  METRC  IPLT  IPRT  NSTAN
      48     0    30     1    0     0      0     0     2      0
                        JOPER       NHT
                            5         0

                          MULTI-PLAN ANALYSES TO BE PERFORMED
                                NPLAN= 1 NRTIO= 9 LRTIO= 1
      RTIOS=    .10   .20   .30   .40   .50   .60   .70   .80  1.00

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

                              SUB-AREA RUNOFF COMPUTATION
      ISTAQ  ICOMP  IECON  ITAPE  JPLT  JPRT  INAME
          1      0      0      0     1     0      0

                                  HYDROGRAPH DATA
      IHYDG  IUHG  TAREA  SNAP  TRSDA  TRSPC  RATIO  ISNOW  ISAME  LOCAL
          0     1  30.00  0.00   0.00   0.00  0.000      0      1      0

                                    PRECIP DATA
                    NP  STORM  DAJ  DAK
                    12   0.00  0.00  0.00
                                PRECIP PATTERN
      0.00   0.00   .30   .50   .70  1.10  3.60  5.90  1.60   .90
      .90    .90

                                    LOSS DATA
      STRKR  DLTKR  RTIOL  ERAIN  STRKS  RTIOK  STRTL  CNSTL  ALSMX  RTIMP
       0.00   0.00   1.00   0.00   0.00   1.00   0.00   0.00   0.00   0.00

                                UNIT HYDROGRAPH DATA
                          TP= 2.70    CP= .48    NTA= 0

                                  RECESSION DATA
                      STRTQ=    0.00    QRCSN=    0.00    RTIOR= 1.00
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 5.84 AND R= 7.77 INTERVALS

      UNIT HYDROGRAPH 45 END-OF-PERIOD ORDINATES, LAG=  2.70 HOURS, CP=  .48  VOL= 1.00
      234.   869.  1746.  2626.  3250.  3443.  3208.  2820.  2479.  2179.
     1916.  1684.  1481.  1302.  1144.  1006.   884.   777.   683.   601.
      528.   464.   408.   359.   315.   277.   244.   214.   188.   166.
      146.   128.   112.    99.    87.    76.    67.    59.    52.    46.
       40.    35.    31.    27.    24.
```

1	1	30	.50	.50	378.
1	1	60	.50	.50	378.
1	2	30	.70	.70	1122.
1	2	60	1.10	1.10	2526.
1	3	30	3.60	3.60	5309.
1	3	60	5.90	5.90	10925.
1	4	30	1.60	1.60	19632.
1	4	60	.90	.90	29769.
1	5	30	.90	.90	39164.
1	5	60	.90	.90	45731.
1	6	30	0.00	0.00	48280.
1	6	60	0.00	0.00	47164.
1	7	30	0.00	0.00	44104.
1	7	60	0.00	0.00	40313.
1	8	30	0.00	0.00	36129.
1	8	60	0.00	0.00	31924.
1	9	30	0.00	0.00	28064.
1	9	60	0.00	0.00	24671.
1	10	30	0.00	0.00	21688.
1	10	60	0.00	0.00	19066.
1	11	30	0.00	0.00	16761.
1	11	60	0.00	0.00	14734.
1	12	30	0.00	0.00	12953.
1	12	60	0.00	0.00	11387.
1	13	30	0.00	0.00	10010.
1	13	60	0.00	0.00	8800.
1	14	30	0.00	0.00	7736.
1	14	60	0.00	0.00	6800.
1	15	30	0.00	0.00	5978.
1	15	60	0.00	0.00	5255.
1	16	30	0.00	0.00	4620.
1	16	60	0.00	0.00	4061.
1	17	30	0.00	0.00	3570.
1	17	60	0.00	0.00	3139.
1	18	30	0.00	0.00	2759.
1	18	60	0.00	0.00	2426.
1	19	30	0.00	0.00	2132.
1	19	60	0.00	0.00	1874.
1	20	30	0.00	0.00	1648.
1	20	60	0.00	0.00	1449.
1	21	30	0.00	0.00	1273.
1	21	60	0.00	0.00	1119.
1	22	30	0.00	0.00	984.
1	22	60	0.00	0.00	865.
1	23	30	0.00	0.00	761.
1	23	60	0.00	0.00	662.
		SUM	16.40	16.40	629809.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	48280.	36419.	13121.	13121.	629812.
INCHES		11.29	16.27	16.27	16.27
AC-FT		18068.	26039.	26039.	26039.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 1

0.	0.	7.	38.	112.	253.	531.	1093.	1963.	2979.
3916.	4573.	4828.	4716.	4411.	4031.	3613.	3192.	2806.	2467.
2169.	1907.	1676.	1473.	1295.	1139.	1001.	880.	774.	680.
598.	526.	462.	406.	357.	314.	276.	243.	213.	187.
165.	145.	127.	112.	98.	87.	76.	66.		

HYDROGRAPH AT STA

0.	0.	14.	76.	224.	505.	1062.	2185.	3926.	5958.
7833.	9146.	9656.	9433.	8822.	8063.	7226.	6385.	5613.	4934.
4338.	3813.	3352.	2947.	2591.	2277.	2002.	1760.	1547.	1360.
1196.	1051.	924.	812.	714.	628.	552.	485.	426.	375.
330.	290.	255.	224.	197.	173.	152.	132.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	9656.	7284.	2624.	2624.	125962.
INCHES		2.26	3.25	3.25	3.25
AC-FT		3614.	5208.	5208.	5208.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 3

0.	0.	21.	113.	337.	758.	1593.	3278.	5890.	8937.
11749.	13719.	14484.	14149.	13232.	12094.	10839.	9577.	8419.	7401.
6506.	5720.	5028.	4420.	3886.	3416.	3003.	2640.	2321.	2040.
1793.	1577.	1386.	1218.	1071.	942.	828.	728.	640.	562.
494.	435.	382.	336.	295.	260.	228.	199.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	14484.	10926.	3936.	3936.	188944.
INCHES		3.39	4.88	4.88	4.88
AC-FT		5420.	7812.	7812.	7812.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 4

0.	0.	28.	151.	449.	1011.	2124.	4370.	7853.	11916.
15666.	18292.	19312.	18865.	17643.	16125.	14452.	12770.	11226.	9868.
8675.	7626.	6704.	5894.	5181.	4555.	4004.	3520.	3094.	2720.
2391.	2102.	1848.	1625.	1428.	1255.	1104.	970.	853.	750.
659.	579.	509.	448.	394.	346.	304.	265.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	19312.	14568.	5248.	5248.	251925.
INCHES		4.52	6.51	6.51	6.51
AC-FT		7227.	10415.	10415.	10415.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 5

0.	0.	35.	189.	561.	1263.	2654.	5463.	9816.	14895.
19582.	22865.	24140.	23582.	22054.	20156.	18065.	15962.	14032.	12336.
10844.	9533.	8380.	7367.	6476.	5693.	5005.	4400.	3868.	3400.
2989.	2628.	2310.	2031.	1785.	1569.	1380.	1213.	1066.	937.
824.	724.	637.	560.	492.	433.	380.	331.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	24140.	18209.	6561.	6561.	314906.
INCHES		5.65	8.14	8.14	8.14
AC-FT		9034.	13019.	13019.	13019.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 6

0.	0.	42.	227.	673.	1516.	3185.	6555.	11779.	17874.
23499.	27438.	28968.	28298.	26465.	24188.	21678.	19155.	16839.	14883.
13013.	11440.	10056.	8841.	7772.	6832.	6006.	5280.	4641.	4080.
3587.	3153.	2772.	2437.	2142.	1883.	1656.	1455.	1279.	1125.
989.	869.	764.	672.	590.	519.	456.	397.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	28968.	21851.	7873.	7873.	377887.
INCHES		6.78	9.76	9.76	9.76
AC-FT		10841.	15623.	15623.	15623.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 2

0.	0.	49.	264.	785.	1768.	3716.	7648.	13742.	20853.
27415.	32011.	33796.	33014.	30875.	28219.	25291.	22347.	19645.	17278.
[illegible]			[illegible]	9067.	7971.	7007.	6168.	5416.	4760.

		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
	CFS	33796.	25493.	9185.	9185.	440869.
	INCHES		7.90	11.39	11.39	11.39
	AC-FT		12648.	18227.	18227.	18227.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 8

0.	0.	56.	302.	898.	2021.	4247.	8740.	15706.	23831.
31331.	36584.	38624.	37731.	35286.	32250.	28903.	25539.	22451.	19737.
17351.	15253.	13409.	11787.	10362.	9109.	8008.	7040.	6189.	5440.
4783.	4204.	3696.	3249.	2856.	2511.	2207.	1940.	1706.	1500.
1318.	1159.	1019.	896.	787.	692.	608.	530.		

		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
	CFS	38624.	29135.	10497.	10497.	503850.
	INCHES		9.03	13.02	13.02	13.02
	AC-FT		14455.	20831.	20831.	20831.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 9

0.	0.	70.	378.	1122.	2526.	5309.	10925.	19632.	29789.
39164.	45731.	48280.	47164.	44108.	40313.	36129.	31924.	28064.	24671.
21668.	19066.	16761.	14734.	12953.	11387.	10010.	8800.	7736.	6800.
5978.	5255.	4620.	4061.	3570.	3139.	2759.	2426.	2132.	1874.
1648.	1449.	1273.	1119.	984.	865.	761.	662.		

		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
	CFS	48280.	36419.	13121.	13121.	629812.
	INCHES		11.29	16.27	16.27	16.27
	AC-FT		18068.	26039.	26039.	26039.

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

HYDROGRAPH ROUTING

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
2	1	0	0	0	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
0.0	0.000	0.00	1	1

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

STORAGE=	0.	57.	143.	260.	406.	790.	1437.	2091.	2462.	0.
OUTFLOW=	0.	413.	1191.	1375.	2379.	6241.	25057.	42240.	51938.	0.

STATION 2, PLAN 1, RTIO 1

0.	0.	1.	7.	24.	66.	151.	324.	684.	1202.
1343.	1970.	2752.	3448.	3833.	3966.	3917.	3740.	3484.	3192.
2891.	2597.	2336.	2147.	1958.	1774.	1600.	1436.	1352.	1313.
1270.	1225.	1132.	914.	747.	618.	517.	436.	378.	331.
291.	255.	224.	197.	173.	152.	133.	117.		

STOR

0.	0.	0.	1.	3.	9.	21.	44.	87.	150.
240.	347.	443.	513.	551.	564.	559.	541.	516.	487.
457.	428.	400.	373.	345.	318.	293.	269.	245.	220.
193.	165.	137.	112.	94.	79.	68.	59.	52.	45.
40.	35.	31.	27.	24.	21.	18.	16.		

STATION 2, PLAN 1, RTIO 2

0.	0.	2.	13.	49.	132.	303.	695.	1240.	1763.
3291.	5083.	6960.	8899.	9070.	8599.	7883.	7075.	6268.	5910.
5471.	4990.	4505.	4038.	3600.	3198.	2833.	2505.	2259.	2059.
1865.	1681.	1509.	1369.	1331.	1289.	1245.	1199.	997.	811.
667.	555.	467.	398.	349.	306.	268.	235.		

STOR

0.	0.	0.	2.	7.	18.	41.	88.	174.	316.
497.	675.	814.	881.	887.	871.	846.	818.	791.	757.
713.	666.	617.	571.	528.	488.	452.	419.	389.	368.
331.	305.	279.	256.	232.	205.	177.	148.	122.	101.
85.	72.	63.	55.	48.	42.	37.	32.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	9070.	6726.	2609.	2609.	125234.
INCHES		2.09	3.24	3.24	3.24
AC-FT		3337.	5178.	5178.	5178.

STATION 2, PLAN 1, RTIO 3

0.	0.	3.	20.	73.	198.	462.	1080.	1433.	3125.
5613.	10216.	13131.	14020.	13773.	12940.	11835.	10615.	9402.	8243.
7286.	6406.	5961.	5535.	5058.	4573.	4103.	3661.	3254.	2884.
2551.	2288.	2088.	1893.	1708.	1534.	1374.	1337.	1296.	1252.
1206.	1033.	838.	688.	571.	479.	407.	356.		

STOR

0.	0.	0.	3.	10.	27.	62.	131.	268.	480.
727.	926.	1027.	1057.	1049.	1020.	982.	940.	898.	860.
826.	795.	762.	720.	672.	624.	578.	534.	493.	457.
423.	393.	364.	335.	308.	283.	259.	236.	209.	182.
153.	126.	104.	87.	74.	64.	56.	49.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	14020.	10322.	3913.	3913.	187842.
INCHES		3.20	4.85	4.85	4.85
AC-FT		5121.	7766.	7766.	7766.

STATION 2, PLAN 1, RTIO 4

0.	0.	4.	26.	98.	264.	643.	1245.	2070.	4643.
9626.	15141.	17887.	18789.	18386.	17260.	15781.	14153.	12536.	11044.
9715.	8542.	7509.	6601.	6040.	5636.	5168.	4684.	4209.	3760.
3345.	2967.	2625.	2335.	2135.	1938.	1750.	1573.	1409.	1345.
1305.	1262.	1216.	1086.	877.	719.	595.	498.		

STOR

0.	0.	1.	4.	13.	36.	82.	177.	361.	631.
906.	1096.	1191.	1222.	1208.	1169.	1118.	1062.	1006.	955.
909.	869.	833.	802.	770.	730.	683.	635.	588.	543.
502.	465.	431.	400.	371.	342.	315.	289.	265.	241.
215.	188.	159.	131.	108.	91.	77.	66.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	18789.	14072.	5218.	5218.	250443.
INCHES		4.36	6.47	6.47	6.47
AC-FT		6981.	10354.	10354.	10354.

STATION 2, PLAN 1, RTIO 5

0.	0.	5.	33.	122.	330.	823.	1321.	2867.	6137.
14342.	19504.	22503.	23522.	22994.	21577.	19727.	17692.	15670.	13805.

1069.	1040.	1349.	1309.	1268.	1227.	1185.	1142.	1099.	1055.
993.	942.	898.	859.	824.	794.	761.	718.	671.	622.
576.	532.	492.	455.	422.	392.	363.	334.	307.	282.
259.	239.	208.	181.	152.	125.	103.	87.		

		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
	CFS	23522.	17846.	6521.	6521.	312987.
	INCHES		5.53	8.09	8.09	8.09
	AC-FT		8854.	12940.	12940.	12940.

STATION 2, PLAN 1, RTIO 6

0.	0.	6.	39.	147.	395.	1004.	1463.	3761.	9144.
17802.	23552.	26928.	28126.	27602.	25999.	23760.	21252.	18810.	16568.
14573.	12813.	11264.	9902.	8705.	7653.	6727.	6091.	5701.	5239.
4755.	4277.	3824.	3404.	3020.	2673.	2366.	2165.	1967.	1778.
1594.	1433.	1351.	1311.	1268.	1223.	1119.	902.		

STOR

0.	0.	1.	5.	20.	54.	122.	273.	544.	898.
1188.	1386.	1508.	1554.	1534.	1473.	1393.	1306.	1222.	1145.
1076.	1016.	963.	916.	874.	838.	806.	775.	736.	698.
642.	595.	558.	508.	470.	436.	405.	375.	346.	319.
293.	268.	244.	219.	192.	163.	135.	111.		

		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
	CFS	28126.	21481.	7822.	7822.	375452.
	INCHES		6.66	9.70	9.70	9.70
	AC-FT		10657.	15523.	15523.	15523.

STATION 2, PLAN 1, RTIO 7

0.	0.	6.	46.	171.	471.	1182.	1761.	4599.	12193.
21150.	27419.	31282.	32777.	32191.	30329.	27812.	24996.	21996.	19342.
17004.	14949.	13141.	11553.	10156.	8928.	7848.	6900.	6160.	5790.
5336.	4852.	4371.	3912.	3484.	3093.	2738.	2420.	2204.	2005.
1814.	1633.	1464.	1358.	1319.	1276.	1232.	1164.		

STOR

0.	0.	1.	6.	23.	63.	142.	316.	627.	995.
1303.	1527.	1674.	1731.	1709.	1638.	1542.	1435.	1332.	1241.
1160.	1089.	1027.	972.	924.	882.	845.	812.	782.	745.
700.	652.	604.	559.	516.	477.	442.	410.	381.	352.
324.	297.	273.	249.	224.	197.	169.	140.		

		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
	CFS	32777.	25104.	9121.	9121.	437827.
	INCHES		7.78	11.31	11.31	11.31
	AC-FT		12455.	18101.	18101.	18101.

STATION 2, PLAN 1, RTIO 8

0.	0.	7.	52.	196.	549.	1225.	2091.	5471.	15291.
24510.	31197.	35710.	37448.	36786.	34661.	31785.	28571.	25349.	22176.
19452.	17049.	15020.	13203.	11607.	10203.	8970.	7885.	6932.	6173.
5807.	5354.	4870.	4389.	3928.	3499.	3106.	2750.	2431.	2211.
2012.	1820.	1639.	1470.	1360.	1320.	1278.	1233.		

STOR

0.	0.	1.	7.	27.	72.	165.	364.	713.	1181.
1419.	1671.	1842.	1908.	1883.	1802.	1693.	1571.	1448.	1338.
1244.	1163.	1092.	1029.	974.	926.	884.	846.	813.	783.
747.	702.	654.	606.	560.	518.	479.	443.	412.	382.
353.	325.	298.	274.	250.	225.	198.	170.		

		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME

STATION 2, PLAN 1, RTIO 9

0.	0.	9.	66.	245.	707.	1296.	2903.	8260.	20600.
30645.	30957.	44614.	46792.	45992.	43330.	39740.	35716.	31647.	27941.
24557.	21422.	18790.	16508.	14509.	12754.	11212.	9856.	8665.	7617.
6696.	6078.	5685.	5222.	4737.	4261.	3808.	3389.	3007.	2661.
2359.	2158.	1960.	1771.	1593.	1427.	1349.	1309.		

STOR

0.	0.	1.	9.	34.	89.	210.	458.	859.	1284.
1650.	1966.	2182.	2265.	2234.	2133.	1996.	1843.	1689.	1547.
1420.	1312.	1222.	1143.	1074.	1014.	961.	914.	873.	837.
805.	773.	734.	688.	640.	593.	548.	507.	469.	434.
403.	374.	345.	318.	292.	267.	244.	218.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	46792.	35949.	13018.	13018.	624858.
INCHES		11.15	16.15	16.15	16.15
AC-FT		17835.	25834.	25834.	25834.

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HYDROGRAPH ROUTING

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
3	1	0	0	0	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
0.0	0.000	0.00	1	1

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

STORAGE=	0.	12.	114.	279.	507.	780.	1149.	1564.	2041.	2874.
OUTFLOW=	0.	55.	1135.	2858.	4392.	8902.	16008.	24872.	35109.	52707.

STATION 3, PLAN 1, RTIO 1

0.	0.	0.	1.	4.	12.	32.	82.	232.	484.
763.	1080.	1534.	2090.	2640.	3016.	3242.	3385.	3441.	3416.
3324.	3182.	3007.	2803.	2537.	2299.	2082.	1882.	1709.	1575.
1475.	1394.	1318.	1213.	1078.	938.	807.	690.	590.	506.
437.	379.	330.	287.	251.	219.	192.	168.		

STOR

0.	0.	0.	0.	1.	2.	6.	13.	28.	52.
79.	109.	153.	206.	258.	303.	336.	358.	366.	362.
349.	327.	302.	274.	249.	226.	205.	186.	169.	156.
147.	139.	132.	122.	109.	95.	83.	72.	62.	54.
47.	42.	37.	33.	29.	26.	24.	22.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3441.	3024.	1294.	1294.	62124.
INCHES		.94	1.61	1.61	1.61
AC-FT		1500.	2568.	2568.	2568.

STATION 3, PLAN 1, RTIO 2

0.	0.	0.	2.	8.	25.	65.	218.	484.	844.
1441.	2415.	3435.	4687.	6872.	7870.	8059.	7764.	7208.	6639.
6157.	5686.	5209.	4732.	4332.	4104.	3838.	3552.	3266.	2995.
2691.	2356.	2092.	1860.	1679.	1548.	1448.	1368.	1272.	1142.

PEAK FLOW SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS

OPERATION	STATION	PLAN	RATIOS APPLIED TO FLOWS .10	.20	.30	.40	.50	.60	.70	.80	1.00
HYDROGRAPH AT	1	1	4828.	9656.	14484.	19312.	24140.	28968.	33796.	38624.	48280.
		2	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROUTED TO	2	1	3966.	9070.	14020.	18789.	23522.	28126.	32777.	37448.	46792.
		2	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROUTED TO	3	1	3441.	8050.	12990.	17672.	22262.	26782.	31261.	35757.	44708.
		2	0.	0.	0.	0.	0.	0.	0.	0.	0.