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GAI CONSULTANTS INC MONROEVILLE PA
NATIONAL DAM INSPECTION PROGRAM. PENELEC RETENTION DAM. (NDI I.--ETC(U)
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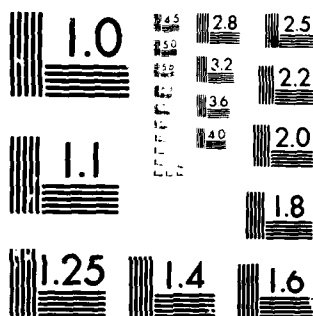
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A high-contrast, black and white image of a classical building facade, possibly a library or museum entrance, featuring prominent columns and a pediment. The image is framed by a thick black border.

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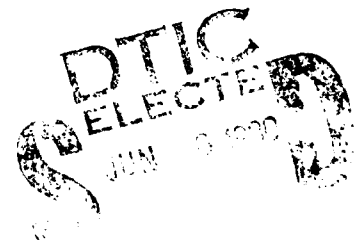
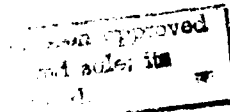
PREFACE

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.



PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

ABSTRACT

Penelec Retention Dam: NDI I.D. No. PA-00809

<u>Owner:</u>	Conemaugh Station Owners Group Pennsylvania Electric Company (operator)
<u>State Located:</u>	Pennsylvania (PennDER I.D. No. 32-78)
<u>County Located:</u>	Indiana
<u>Stream:</u>	Unnamed Tributary to the Conemaugh River
<u>Inspection Date:</u>	4 and 21 February 1980
<u>Inspection Team:</u>	GAI Consultants, Inc. 570 Beatty Road Monroeville, Pennsylvania 15146

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

The size classification of the facility is small and its hazard classification is considered to be high. In accordance with the recommended guidelines, the Spillway Design Flood (SDF) for the facility ranges between the 1/2 PMF (Probable Maximum Flood) and the PMF. Due to the high potential for damage to downstream structures and loss of life, the SDF for the facility is considered to be the PMF. Results of the hydrologic and hydraulic analysis indicate the facility will pass and/or store a flood of PMF magnitude. Consequently, the spillway is considered adequate.

It is recommended that the owner:

- a. Regrade the embankment crest to restore local low spots to design elevation.
- b. Visually assess cracking noted in the spillway structure in future inspections and make remedial repairs if necessary.

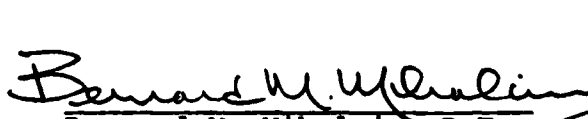
c. Clean excess debris from the concrete gutter along the toe of the dam.

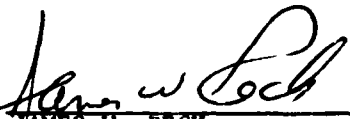
d. Develop a formal warning system for the notification of downstream inhabitants should hazardous embankment conditions develop. Included in the plan should be provisions for around-the-clock surveillance of the facility during periods of unusually heavy precipitation.

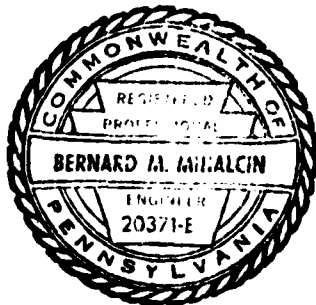
e. Develop formal manuals of maintenance and operation to ensure continued proper care and maintenance of the facility.

GAI Consultants, Inc.

Approved by:


Bernard M. Mihalcin, P.E.


JAMES W. PECK
Colonel, Corps of Engineers
District Engineer



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OVERVIEW PHOTOGRAPH

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
PENELEC RETENTION DAM
NDI# PA-00809, PENNDER# 32-78

SECTION 1
GENERAL INFORMATION

1.0 Authority.

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.

1.1 Purpose.

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

1.2 Description of Project.

a. Dam and Appurtenances. Penelec Retention Dam is an earth embankment approximately 590 feet long, including spillway, with a curved crest and a height of about 27 feet. Its appurtenances consist of a 56-foot long concrete side channel spillway, a concrete and gabion-lined spillway channel, a grass-lined trapezoidal-shaped diversion canal, a small gabion-lined diversion dike, and 2 gated 24-inch diameter reinforced concrete outlet pipes. One of the outlet conduits can be utilized to drain the reservoir.

b. Location. Penelec Retention Dam is located on an unnamed tributary to the Conemaugh River in West Wheatfield Township, Indiana County, Pennsylvania. The embankment is situated approximately 1.3 miles north of New Florence, Pennsylvania, just upstream of the Conemaugh Generating Station. The dam, reservoir, and watershed are contained within the New Florence, Pennsylvania, 7.5 minute U.S.G.S. topographic quadrangle (see Figure 1, Appendix E). The coordinates of the dam are N40° 23.8' and W79° 4.0'.

c. Size Classification. Small (27 feet high, 57 acre-feet storage capacity at top of dam).

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

- e. Ownership. Conemaugh Station Owners Group operated by:

Pennsylvania Electric Company
1001 Broad Street
Johnstown, Pennsylvania 15907
Attention: Mr. R. T. Gallus
Supervisor, Generating
Plant Civil Engineering

f. Purpose. The purpose of the retention embankment is to collect and contain storm runoff which comes in contact with leachate from the upstream solid waste disposal area so that it may be treated prior to being discharged downstream.

g. Historical Data. Penelec Retention Dam was designed by E. D'Appolonia Consulting Engineers, Inc., of Pittsburgh, Pennsylvania. Construction of the facility began in September 1973, by R and L Construction of New Alexandria, Pennsylvania, and was completed on October 25, 1974. The facility has operated virtually problem-free since its completion and no subsequent major modifications have been made.

1.3 Pertinent Data.

- a. Drainage Area (square miles). 1.24
b. Discharge at Dam Site.

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

Discharge Capacity of Spillway at Maximum Pool = 2430 cfs (see Appendix D, Sheet 9).

c. Elevation (feet above mean sea level). The following elevations were obtained from available drawings and through field measurements based on the elevation of the spillway crest at 1150 feet. (Note: There is no defined design normal pool associated with this facility. The treatment plant operates on a continuous basis, causing a constant pool level fluctuation).

Top of Dam	1156.0 (design).
	1154.9 (field).
Maximum Design Pool	1153.1
Maximum Pool of Record	Not known.
Spillway Crest	1150.0
Upstream Outlet Invert	1133.0
Downstream Outlet Invert	1128.2 (field).
Streambed at Dam Centerline	1130.0
Maximum Tailwater	Not known

d. Reservoir Length (feet).

Top of Dam	1600
Spillway Crest	1200

e. Storage (acre-feet).

Top of Dam	57
Spillway Crest	30
Design Pool	46
Design Surcharge	11

f. Reservoir Surface (acres).

Top of Dam	4.9
Spillway Crest	3.7
Maximum Design Pool	4.5

g. Dam.

Type	Homogeneous earth.
Length	534 feet (excluding spillway).
Height	27 feet (field measured; crest to downstream blowoff outlet invert).
Top Width	15 feet (field). 12 feet (design).
Upstream Slope	2.5H:1V
Downstream Slope	2.5H:1V
Zoning	Homogeneous earth with downstream drainage blanket and toe drain.
Impervious Core	None indicated.
Cutoff	Cutoff trench reportedly excavated to a depth of 5 feet along the embankment centerline and back-filled with impervious material. The trench is 15 feet

	Grout Curtain	None indicated.
h.	<u>Diversion Canal and Regulating Tunnels.</u>	Trapezoidal-shaped, grass-lined diversion canal located along left side of reser- voir.
i.	<u>Spillway.</u>	
	Type	Uncontrolled, rein- forced concrete, side channel spill- way with ogee-shaped crest.
	Crest Elevation	1150 feet.
	Crest Length	56 feet.
j.	<u>Outlet Conduit.</u>	
	Type	24-inch diameter reinforced concrete pipe.
	Length	165 feet.
	Closure and Regulating Facilities	Flow through the blowoff can be regu- lated by a 24-inch diameter sluice gate at the inlet and a 24-inch diameter gate valve near the outlet at the down- stream toe.
	Access	The outlet conduit control mechanisms are both accessible by foot at the crest and downstream embankment toe.

SECTION 2 ENGINEERING DATA

2.1 Design.

a. Design Data Availability and Sources. Formal design data is contained in a report dated August 1972, by E. D'Appolonia Consulting Engineers, Inc., entitled "Engineer's Report, Retention Pond Embankment, Conemaugh Station Ash and Mine Refuse Disposal Area." This report is available from both the owner and the PennDER. A brief report by PennDER, dated December 22, 1972, summarizes the various design aspects of the facility and is contained in PennDER files.

b. Design Features.

1. Embankment. The embankment is a homogeneous earthfill structure. The top width is 15 feet while the slopes of both the upstream and downstream faces are 2.5H:1V. The crest is covered with a layer of crushed stone. Other major design considerations include: 1) a cutoff trench along the longitudinal axis; 2) a drainage blanket, toe drain, and paved gutter along the downstream toe; and 3) riprap protection for the upstream embankment face (see Figures 3 and 4).

2. Appurtenant Structures.

a) Spillway. The spillway is an uncontrolled, reinforced concrete, rectangular side-channel type overflow with an ogee-shaped crest located at the left abutment. The weir discharges into a concrete, rectangular spillway channel that provides positive protection for the eastern downstream slope of the embankment. Beyond the concrete channel, the spillway discharge channel is trapezoidal in cross section and lined with gabions. The trapezoidal section has a base width of 20 feet and side slopes of 2H:1V (see Figures 3, 6, and 7).

b) Outlet Works. Two 24-inch diameter reinforced concrete pipes, gated at the upstream end and valved at the downstream embankment toe, comprise the outlet works. The gates are heavy duty sluice gates with stainless steel riser stems and corrosion resistant seating faces. Both pipes direct flow into the treatment facilities, but, the left pipe can be utilized as a blowoff (see Figures 3, 4, and 5).

c) Diversion Canal System. The facility is provided with a diversion canal system consisting of a

trapezoidal-shaped earth channel that traverses the eastern slope of the ponding area and a small gabion-lined dike approximately 1,000 feet upstream of the embankment. The canal system is designed to discharge flows of up to 250 cfs from the east basin. The base width of the ditch is 10 feet with 2H:1V side slopes. The canal is designed to flow about 5 feet deep on a slope of .0001 feet per foot (see Figures 2, 3, and 7). Flows in excess of the canal capacity overtop the gabion-lined dike and enter the retention pond.

c. Specific Design Data and Criteria.

1. Hydrology and Hydraulics. Utilizing 6-hour precipitation data from U. S. Weather Bureau and Soil Conservation Service (SCS) rainfall and runoff distributions, the design storm was developed from the 100-year recurrence storm. Peak discharges of 840 and 559 cfs resulted for the main basin and east basin, respectively. These values are slightly in excess of the Pennsylvania "C" Curve criterion. In addition, a freeboard hydrograph was constructed from the SCS Class "A" freeboard storm. The freeboard storm gives peak discharges of 1090 and 775 cfs for the main basin and east basin, respectively. The design and freeboard hydrographs and area-volume curves for the pond are shown on Figure 8.

Flow attenuation due to storage is minimal; consequently, the design assumed outflow to equal inflow. Considering the diversion canal, the peak outflows over the spillway were 1149 and 1615 cfs for the design storm and freeboard storm, respectively.

2. Embankment. The consultant performed a detailed stability analysis of the embankment for the conditions at the end of construction, steady-state seepage at normal pool, and rapid drawdown from normal pool (see Figure 8). Soil parameters utilized in the analysis are presented in Figure 10.

3. Appurtenant Structures. Design aspects of the appurtenances reportedly conform, in general, to the criteria and procedures contained in "Construction or Repair of Dams" by the Water and Power Resources Board of the Pennsylvania Department of Forests and Waters, 1964. Specific design data is contained within the engineer's report available from the owner and the PennDER.

2.2 Construction Records.

Design drawings, contract specifications, several

construction photographs, and construction progress reports are contained in PennDER files.

2.3 Operational Records.

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

2.4 Other Investigations.

No formal investigations have been performed on the facility subsequent to its completion. The owner has recently surveyed the facility and is currently preparing plan drawings.

2.5 Evaluation.

The data available 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 suggests it to be adequately maintained and in good condition.

b. Embankment. Observations made during the visual inspection indicate the embankment is in good condition. No evidence of sloughing, seepage through the downstream embankment face, animal burrows, or signs of serious maintenance neglect were observed (see Photographs 3 and 4). Local settlements slightly in excess of 1-foot were field measured adjacent the right wingwall of the spillway and excess debris has accumulated in the concrete gutter along the downstream embankment toe to the right of the outlet.

c. Appurtenant Structures.

1. Spillway. The visual inspection revealed the spillway is in good condition. Some minor cracking was observed along the channel sidewalls, particularly at the weepholes.

2. Outlet Works. Both 24-inch diameter conduits that comprise the outlet works are reportedly functional; however, neither was operated in the presence of the inspection team. All exposed valve mechanisms appear to be well maintained and in good condition as does the outlet headwall (see Photographs 1, 3, 5 and 6).

3. Diversion Canal System. The diversion canal and upstream diversion dike are considered to be in excellent condition. No conditions were observed that would be expected to significantly hinder the proper functioning of the system (see Photographs 8, 9, 10).

d. Reservoir Area. The topography of the general area surrounding the reservoir gently rises in elevation to the east and more steeply to the west. The adjacent slopes are, for the most part, brush covered or lightly wooded. No evidence of slope distress was observed.

e. Downstream Channel. The embankment is situated in a north-south trending stream valley. The stream flows to the south and is a tributary to the Conemaugh River. Approximately 1/2-mile below the embankment the stream passes

within several hundred feet of the facilities comprising the Conemaugh Generating Station. The community of Centerville, Pennsylvania is located about 1-mile downstream of the embankment along a low area adjacent the Conemaugh River. A breach of the embankment would likely result in significant economic damage at the generating station and possibly the loss of many lives in Centerville. Consequently, the hazard classification of this facility is considered to be high.

3.2 Evaluation.

The overall condition of the facility is considered to be good. Deficiencies noted by the inspection team included minor cracking along the spillway channel sidewalls, particularly at the weepholes, local embankment settlement slightly in excess of 1-foot adjacent the right wingwall of the spillway, and excess debris in the paved gutter along the downstream embankment toe to the right of the outlet.

SECTION 4 OPERATIONAL PROCEDURES

4.1 Normal Operating Procedure.

The facility is essentially self-regulating. Normal leachate flow from the ash disposal site is designed to pass unattenuated through the impoundment to the treatment plant. Runoff from storms of 3-year return or less are entirely retained by the impoundment. Additional runoff from storms in excess of this is discharged through the spillway system. The treatment plant, located immediately below the embankment, operates on a continuous basis acting to drawdown any ponded storm water. Consequently, normal pool is undefined at this facility. The diversion canal routes low flow runoff (up to 250 cfs) from the east basin around the impoundment.

4.2 Maintenance of Dam.

The dam is maintained on an informal as-needed basis. No formal operations or maintenance manuals are 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.

The facility is designed to be essentially self-regulating and to require minimal maintenance. Formal operations and maintenance manuals need to be developed and a formal warning system put in effect.

SECTION 5 HYDROLOGIC/HYDRAULIC EVALUATION

5.1 Design Data.

The hydraulic structures, as provided in the design, include a single concrete side channel spillway, a diversion canal system, and outlet works. The design aspects reportedly conform, in general, to the procedures and criteria contained in the reference, "Construction or Repair of Dams," by the Water and Power Resources Board of the Pennsylvania Department of Forests and Waters, 1964. Specific design data are contained in the engineer's report available from the owner and the PennDER.

5.2 Experience Data.

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

5.3 Visual Observations.

On the date of the inspection, no conditions were observed that would indicate the spillway could not perform satisfactorily during a flood event, within the limits of its design capacity.

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 Penelec Retention Dam ranges between the 1/2 PMF (Probable Maximum Flood) and

the PMF. This classification is based on the relative size of the dam (small) and the potential hazard of dam failure to downstream developments (high). Due to the high potential for damage to downstream structures and possibly loss of life, the SDF for this facility is considered to be the PMF.

b. Results of Analysis. Penelec Retention Dam was evaluated under near normal design operating conditions. That is, the reservoir was initially drawn down to the zero storage elevation of approximately 1133.0 feet. The outlet conduits were assumed to be non-functional for the purpose of analysis, since the flow capacities of these conduits are not such that they would significantly increase the total discharge capabilities of the facility. The spillway consists of a concrete side-channel ogee-type weir, which discharges freely into a rectangular concrete channel. The diversion canal, which by-passes the spillway, was assumed to be capable of conveying up to 250 cfs of runoff from the east basin, as designed. 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 Penelec Retention Dam can accommodate storms in excess of the PMF. The maximum spillway capacity of 2430 cfs (Appendix d, Sheet D) was found to be in excess of the peak PMF inflow of approximately 2425 cfs (Appendix D, Summary Input/Output Sheets, Sheet G). The peak PMF inflow was essentially not attenuated by the discharge/storage capabilities of the dam, as the resulting PMF peak outflow was about 2422 cfs (Appendix D, Summary Input/Output Sheets, Sheet F).

5.6 Spillway Adequacy.

Penelec Retention Dam was found to be capable of accommodating its SDF (the PMF), and therefore, its spillway is considered to be adequate.

SECTION 6 EVALUATION OF STRUCTURAL INTEGRITY

6.1 Visual Observations.

a. Embankment. Based on visual observations, the embankment is in good condition. Local low spots along the crest should be graded and restored to design elevation.

b. Appurtenant Structures.

1. Spillway. Visual observations indicate the spillway is in good condition. Cracks noted in the spillway sidewalls do not appear significant, presently, but should be specifically addressed in future inspections.

2. Outlet Works. The outlet works are reportedly functional and appear to be well maintained and in good condition.

3. Diversion Canal System. The diversion canal system was observed in excellent condition. No adverse conditions were noted by the inspection team.

6.2 Design and Construction Techniques.

Correspondence, specifications, contract drawings, and construction progress reports indicate that the facility was designed and constructed in accordance with generally accepted modern practices.

6.3 Past Performance.

According to available correspondence and discussions with the owner's representative, the facility has performed satisfactorily since its completion.

6.4 Seismic Stability.

The dam is located in Seismic Zone No. 1 and may be subject to minor earthquake induced dynamic forces. As the facility appears well constructed and sufficiently stable, it is believed that it can withstand the expected dynamic forces; however, no calculations and/or investigations were performed to confirm this belief.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS FOR REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety. The visual inspection suggests the facility is adequately designed and in good condition.

The size classification of the facility is small and its hazard classification is considered to be high. In accordance with the recommended guidelines, the Spillway Design Flood (SDF) for the facility ranges between the 1/2 PMF (Probable Maximum Flood) and the PMF. Due to the high potential for damage to downstream structures and loss of life, the SDF for the facility is considered to be the PMF. Results of the hydrologic and hydraulic analysis indicate the facility will pass and/or store a flood of PMF magnitude. Consequently, the spillway is considered adequate.

Deficiencies noted by the inspection team included local settlement slightly in excess of 1-foot along the embankment crest adjacent to the right spillway wingwall, minor cracking of the spillway channel walls, and excess debris in the paved gutter along the toe of the embankment to the right of the outlet.

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

c. Urgency. The recommendations listed below should be implemented immediately.

d. Necessity for Additional Investigations. No additional investigations are currently deemed necessary.

7.2 Recommendations/Remedial Measures.

It is recommended that the owner:

a. Regrade the embankment crest and restore local low spots to design elevation.

b. Visually assess cracking noted in the spillway structure in future inspections and make remedial repairs if necessary.

c. Clean excess debris from the concrete gutter along the toe of the dam.

d. Develop a formal warning system for the notification of downstream inhabitants should hazardous embankment conditions develop. Included in the plan should be provisions for around-the-clock surveillance of the facility during periods of unusually heavy precipitation.

e. Develop formal manuals of maintenance and operation to ensure continued proper care and maintenance of the facility.

APPENDIX A

VISUAL INSPECTION CHECKLIST AND FIELD SKETCHES

CHECK LIST VISUAL INSPECTION PHASE 1

NAME OF DAM Penelec Retention Dam STATE Pennsylvania COUNTY Indiana

NDI # PA -- 00809 PENNDR # 32-78

TYPE OF DAM Earth SIZE Small HAZARD CATEGORY High

DATE(S) INSPECTION 4 February 1980 WEATHER Cold, clear TEMPERATURE 20° @ 2:00 p.m.

POOL ELEVATION AT TIME OF INSPECTION 1141.4 M.S.L.

TAILWATER AT TIME OF INSPECTION - M.S.L.

INSPECTION PERSONNEL	OWNER REPRESENTATIVES	OTHERS
<u>B. M. Mihalcin</u>	<u>Penelec Personnel</u>	<u></u>
<u>D. J. Spaeder</u>	<u>R. T. Gallus</u>	<u></u>
<u>D. L. Bonk</u>	<u></u>	<u></u>
<u>Site Revisited and Rephotographed</u>	<u></u>	<u></u>
<u>by B. M. Mahalcin 21 February 1980</u>	<u></u>	<u></u>

RECORDED BY B. M. Mihalcin

EMBANKMENT

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDI# PA - 00809
SURFACE CRACKS	None observed.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None observed.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Local low area slightly in excess of 1-foot adjacent to spillway right wingwall. Curved centerline.	
RIPRAP FAILURES	None observed. Riprap is durable, well-graded Loyalhanna Limestone.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Embankment to abutments, good. Concrete-lined gutter along entire downstream toe. Excess debris in gutter along downstream embankment toe to right of outlet.	

EMBANKMENT

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDI# PA - 00809
DAMP AREAS IRREGULAR VEGETA- TION (LUSH OR DEAD PLANTS)	None observed.	
ANY NOTICEABLE SEEPAGE	None observed.	
STAFF GAGE AND RECORDER	None.	
DRAINS	None.	

OUTLET WORKS

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDI# PA - 00809
INTAKE STRUCTURE	Submerged, not observed.	
OUTLET CONDUIT (CRACKING AND SPALLING OF CON- CRETE SURFACES)	Headwall in excellent condition.	
OUTLET STRUCTURE	See above.	
OUTLET CHANNEL	Gabion-lined trapezoidal channel. Excellent condition.	
GATE(S) AND OPERA- TIONAL EQUIPMENT	Two gate operators on upstream face of dam in excellent condition. Two valve operators near downstream toe in excellent condition.	

EMERGENCY SPILLWAY

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDI# PA - 00809
TYPE AND CONDITION	Ogee-type concrete side channel spillway discharges into rectangular concrete channel. Good conditions.	
APPROACH CHANNEL	Rock-lined, unobstructed.	
SPILLWAY CHANNEL AND SIDEWALLS	Generally in good condition. Sidewalls well-aligned but exhibiting several vertical cracks at weephole locations, particularly in upstream diversion canal. Should be observed in future inspections and sealed as required.	
STILLING BASIN PLUNGE POOL	None.	
DISCHARGE CHANNEL	Gabion-lined trapezoidal channel. Excellent condition.	
BRIDGE AND PIERS EMERGENCY GATES	None.	

SERVICE SPILLWAY

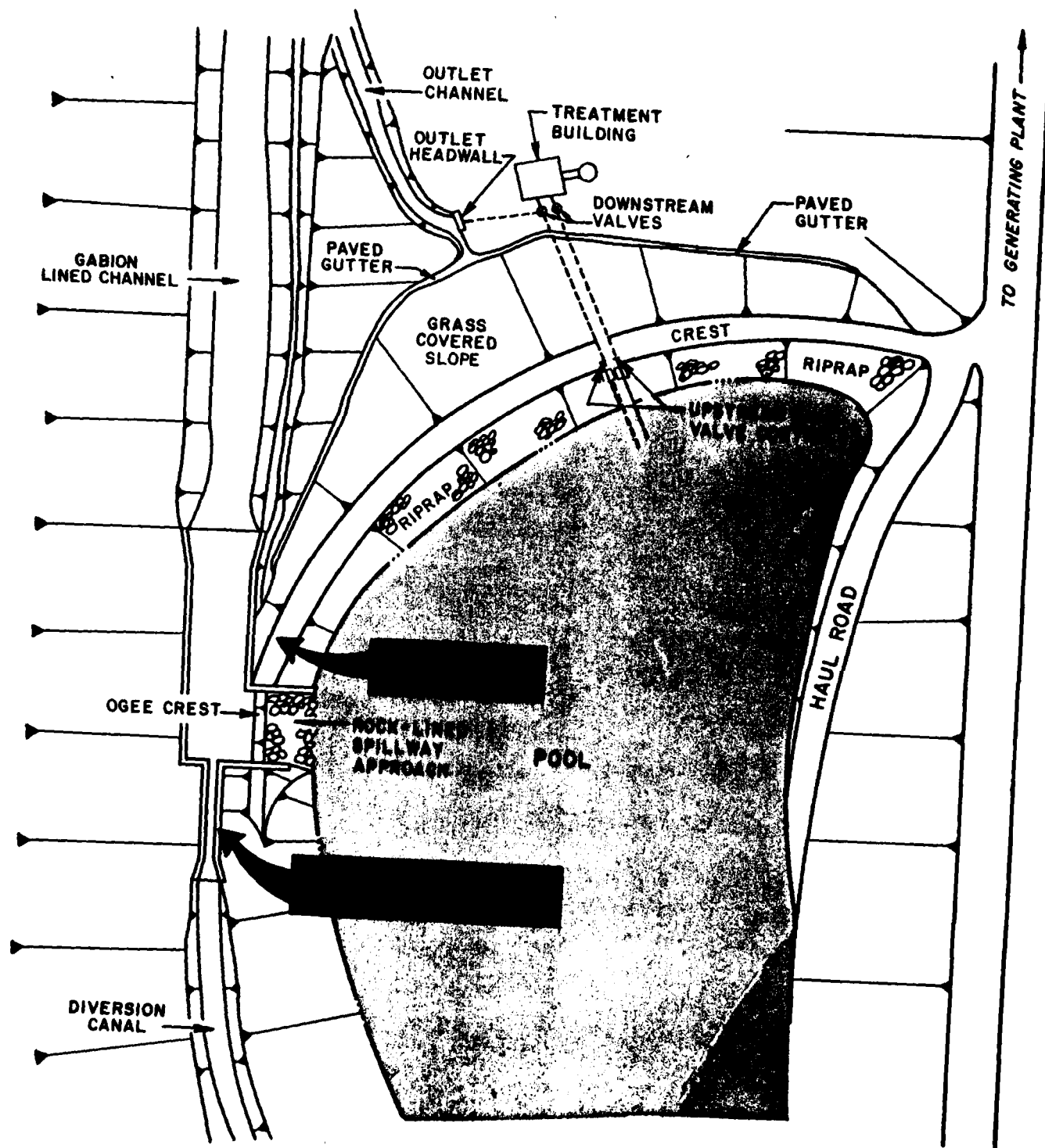
ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDI# PA - 00809
TYPE AND CONDITION	N/A.	
APPROACH CHANNEL	N/A.	
OUTLET STRUCTURE	N/A.	
DISCHARGE CHANNEL	N/A.	

INSTRUMENTATION

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDI# PA - 00809
MONUMENTATION SURVEYS	Owner has recently surveyed entire dam and reservoir area. Detailed drawings are being prepared.	
OBSERVATION WELLS	None.	
WEIRS	None.	
PIEZOMETERS	None.	
OTHERS		

RESERVOIR AREA AND DOWNSTREAM CHANNEL

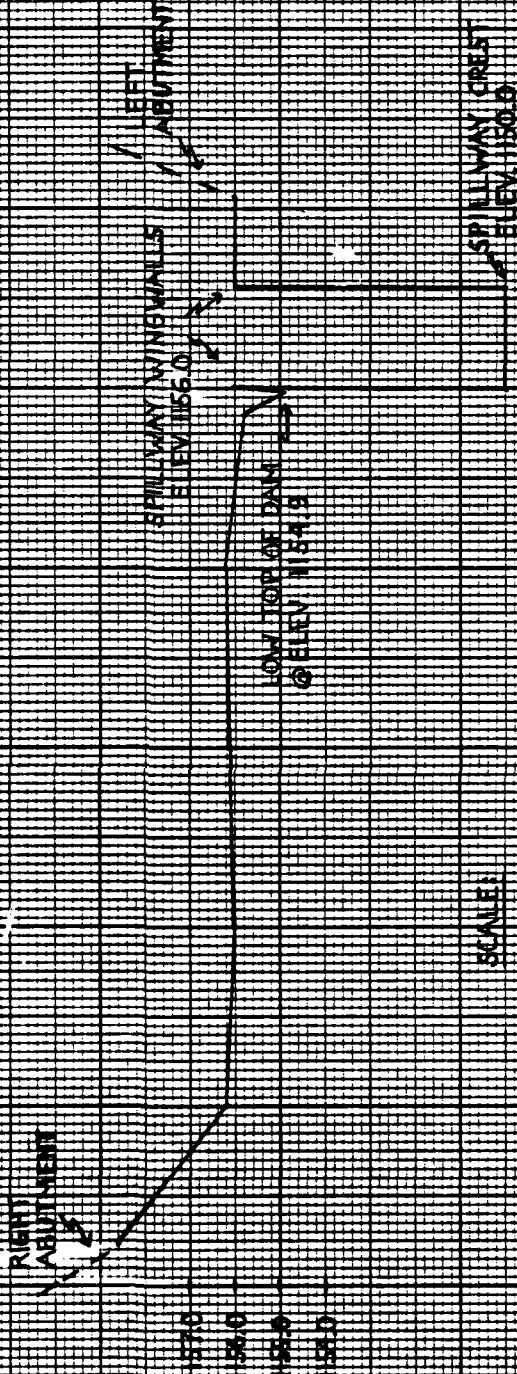
ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDI# PA - 00809
SLOPES: RESERVOIR	Slopes are moderate to steep, and are grass-covered to lightly wooded.	
SEDIMENTATION	No significant sedimentation. Owner dredges reservoir area to control sedimentation.	
DOWNSTREAM CHANNEL (OBSTRUCTIONS, DEBRIS, ETC.)	Road bridges are located about 1/2-mile and 1-mile downstream from the dam. The stream runs adjacent to the community of Centerville, about 1-mile downstream from the dam, and discharges into the Conemaugh River.	
SLOPES: CHANNEL VALLEY	The channel slope is generally mild (on the order of 1 percent) within the downstream reach. The stream valley is broad in sections, with mild to steep side slopes.	
APPROXIMATE NUMBER OF HOMES AND POPULATION	Effluent treatment plant near toe of dam. About 1/2-mile below the embankment the stream passes within several hundred feet of the facilities comprising the Conemaugh Generating Station. The community of Centerville, Pennsylvania is about 1-mile downstream of the embankment. An embankment breach would likely result in significant economic damage and possibly the loss of many lives in Centerville.	



**PENELEC RETENTION DAM
GENERAL PLAN - FIELD INSPECTION NOTES**

PENELPIC RETENTION DAM

PROFILE OF DAM CREST
FROM FIELD SURVEY



SCALE:

VERTICAL: 1" = 4 FT

HORIZONTAL: 1" = 100 FT

APPENDIX B
ENGINEERING DATA CHECKLIST

**CHECK LIST
ENGINEERING DATA
PHASE I**

NAME OF DAM Penelec Retention Dam

ITEM	REMARKS	NDI# PA - 00809
PERSONS INTERVIEWED AND TITLE	Pennsylvania Electric Company. R. T. Gallus (Supervisor, Generating Plant Civil Engineering).	
REGIONAL VICINITY MAP	See Appendix E, Figure 1.	
CONSTRUCTION HISTORY	Designed by E. D'Appolonia Consulting Engineers, Inc., of Pittsburgh, Pennsylvania. Constructed in 1973-1974 by R and L Construction of New Alexandria, Pennsylvania.	
AVAILABLE DRAWINGS	Complete set of design drawings dated 1972 by D'Appolonia available from the owner and the PennDER (see Appendix E, Figures 2 through 10).	
TYPICAL DAM SECTIONS	See Appendix E, Figures 4 and 5.	
OUTLETS: PLAN DETAILS DISCHARGE RATINGS	See Appendix E, Figure 5. Discharge curves are not available.	

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

ITEM	REMARKS	ND# PA - 00809
SPILLWAY: PLAN SECTION DETAILS	See Appendix E, Figures 6 and 7.	
OPERATING EQUIP. MENT PLANS AND DETAILS	See Appendix E, Figure 5.	
DESIGN REPORTS	Report by E. D'Appolonia Consulting Engineers, Inc., dated August 1972, entitled "Engineer's Report, Retention Pond Embankment, Conemaugh Station Ash and Mine Refuse Disposal Area" available from the owner and the PennDER.	
GEOLOGY REPORTS	See design report. See Appendix E, Figure 9.	
DESIGN COMPUTATIONS: HYDROLOGY AND HYDRAULICS STABILITY ANALYSES SEEPAGE ANALYSES	See design report. See Appendix E, Figure 8.	
MATERIAL INVESTIGATIONS: BORING RECORDS LABORATORY TESTING FIELD TESTING	See Appendix E, Figures 9 and 10.	

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

ITEM	REMARKS	NDI# PA - 00809
BORROW SOURCES	See Appendix E, Figure 2.	
POST CONSTRUCTION DAM SURVEYS	Recently completed survey. Drawings are currently being prepared.	
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None.	
HIGH POOL RECORDS	None available.	
MONITORING SYSTEMS	None.	
MODIFICATIONS	None.	

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

ITEM	REMARKS	NDI# PA - 00809
PRIOR ACCIDENTS OR FAILURES	None.	
MAINTENANCE: RECORDS MANUAL	Maintenance performed as-needed. No formal records or manual are available.	
OPERATION: RECORDS MANUAL	No formal records or manual are available.	
OPERATIONAL PROCEDURES	Essentially self-regulating. Water is drawn through the outlets on continuous basis to be treated and released.	
WARNING SYSTEM AND/OR COMMUNICATION FACILITIES	None presently in effect.	
MISCELLANEOUS		

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**CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA**

NDI ID # PA-00809
PENNER ID # 32-78

SIZE OF DRAINAGE AREA: 1.24 square miles.
ELEVATION TOP NORMAL POOL: 1150.0 STORAGE CAPACITY: 30 acre-feet.
ELEVATION TOP FLOOD CONTROL POOL: - STORAGE CAPACITY: -
ELEVATION MAXIMUM DESIGN POOL: - STORAGE CAPACITY: -
ELEVATION TOP DAM: 1154.9 STORAGE CAPACITY: 57 acre-feet.

SPILLWAY DATA

CREST ELEVATION: 1150.0 feet.
TYPE: Ogee-crested side channel.
CREST LENGTH: 56 feet.
CHANNEL LENGTH: 151 feet.
SPILLOVER LOCATION: Left abutment.
NUMBER AND TYPE OF GATES: None.

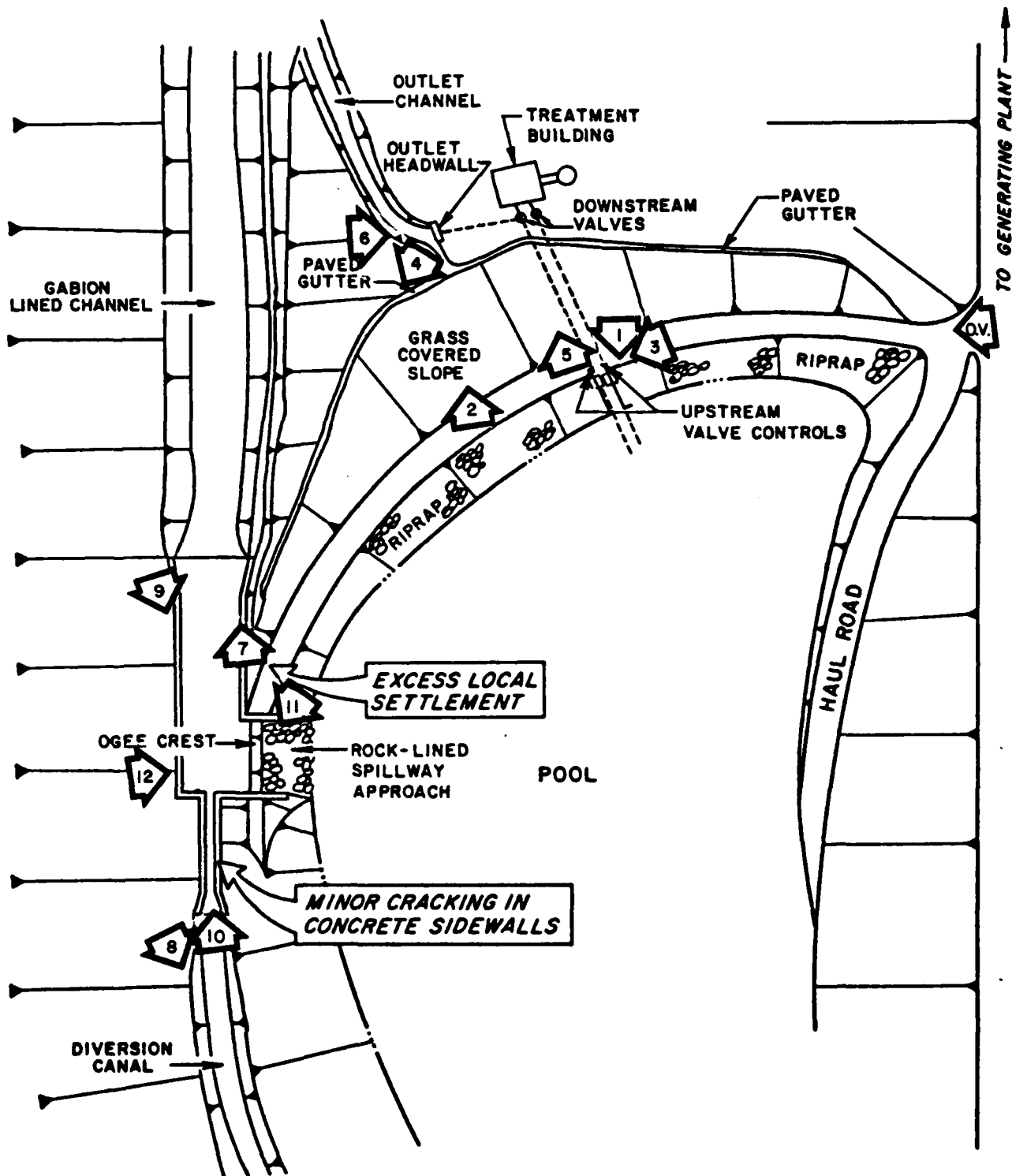
OUTLET WORKS

TYPE: Two 24-inch diameter reinforced concrete pipes.
LOCATION: Near center of embankment.
ENTRANCE INVERTS: 1133.0 feet.
EXIT INVERTS: 1128.2 feet (blowoff).
EMERGENCY DRAWDOWN FACILITIES: Blowoff gated at inlet and valved at outlet.

HYDROMETEOROLOGICAL GAGES

TYPE: None.
LOCATION: -
RECORDS: -
MAXIMUM NON-DAMAGING DISCHARGE: Not known.

APPENDIX C
PHOTOGRAPHS



**PENELEC RETENTION DAM
PHOTOGRAPH KEY MAP**

PHOTOGRAPH 1 View of the reservoir and upstream gate operators as seen from embankment crest.

PHOTOGRAPH 2 View of the area immediately downstream of the embankment. The outlet discharge channel is in the center of the view.

PHOTOGRAPH 3 View of the upstream embankment slope and gate operators as seen from the right abutment.

PHOTOGRAPH 4 View of the downstream embankment slope to the left of the outlet. Paved gutter runs along the entire downstream toe.



4



2



3



1

PHOTOGRAPH 5 View of the treatment building and gate valve control mechanisms located immediately below the embankment.

PHOTOGRAPH 6 View of the discharge end of the blowoff outlet located at the downstream embankment toe.

PHOTOGRAPH 7 View of the rectangular, concrete spillway channel and trapezoidal-shaped, gabion-lined discharge channel.

PHOTOGRAPH 8 View of the trapezoidal-shaped, grass-lined diversion canal.



PHOTOGRAPH 9 View, looking upstream, of the spillway channel as seen from the left abutment.

PHOTOGRAPH 10 View, looking downstream, of the spillway channel as seen from the concrete-lined portion of the diversion canal.

PHOTOGRAPH 11 View of the spillway forebay area.

PHOTOGRAPH 12 Front view of the ogee-crested spillway weir.



9



10



11



12

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: PENELEC RETENTION DAM

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

STATION	1	2	3
STATION DESCRIPTION	PENELEC RETENTION DAM		
DRAINAGE AREA (SQUARE MILES)	0.91	0.33 ⁽⁵⁾	
CUMULATIVE DRAINAGE AREA (SQUARE MILES)	1.24		
ADJUSTMENT OF PMF FOR DRAINAGE AREA LOCATION (%) ⁽¹⁾			
6 HOURS	102		
12 HOURS	120		
24 HOURS	130		
48 HOURS	140		
72 HOURS	-		
SNYDER HYDROGRAPH PARAMETERS			
ZONE (2)	24		
C _p (3)	0.45		
C _t (3)	1.6		
L (MILES) (4)	1.85	0.82 ⁽⁵⁾	
L _{ca} (MILES) (4)	1.00	0.38	
t _p = C _t (L · L _{ca}) ^{0.3} (HOURS)	1.92	1.13	
SPILLWAY DATA			
CREST LENGTH (FEET)	56		
FREEBOARD (FEET)	4.9		

(1) HYDROMETEOROLOGICAL REPORT 33, U.S. ARMY CORPS OF ENGINEERS, 1956.

(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.

(5) MAIN BASIN/EAST BASIN

PROJECT DAM SAFETY INSPECTION
PENELEC RETENTION DAM
BY ZTS DATE 2-25-80 PROJ. NO. 79-203-809
CHKD. BY DLB DATE 2-28-80 SHEET NO. 1 OF 13



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DAM STATISTICS

- HEIGHT OF DAM = 27 FT

(FIELD MEASURED)

- NORMAL POOL STORAGE CAPACITY = 1.3×10^6 CUBIC FEET
= 29.8 ACRE-Feet

(SEE NOTE 1)

- MAXIMUM POOL STORAGE CAPACITY = 57 ACRE-FT
(AT LOW TOP OF DAM)

(SEE NOTE 1)

- DRAINAGE AREA :

MAIN BASIN : 0.91 SQ. MI.

EAST BASIN : 0.33 SQ. MI.

TOTAL : 1.24 SQ. MI.

(PLANIMETERED ON USGS 7.5'
TOPO QUAD: NEW FLEMING, PA)

- ELEVATION OF TOP OF DAM (FIELD) = 1154.9

- ELEVATION OF TOP OF DAM (DESIGN) = 1156.0

(FIGURE 4)

- NORMAL POOL ELEVATION = 1150.0

(FIGURE 4)

- UPSTREAM INLET INVERT ELEVATION = 1133.0

(FIGURE 5)

- DOWNSTREAM OUTLET INVERT = 1128.2

(FIELD MEASURED)

- STREAMBED AT DAM CENTERLINE = 1130.0

(FIGURE 3)

PROJECT DAM SAFETY INSPECTION
PENELEC RETENTION DAM
 BY DES DATE 2-25-80 PROJ. NO. 79-203-809
 CHKD. BY DLB DATE 2-28-80 SHEET NO. 2 OF 13



NOTE 1: VALUES OBTAINED FROM "ENGINEER'S REPORT - RETENTION POND
 EMBANKMENT, CONEMAUGH STATION, ASH AND MINE REFUSE DISPOSAL AREA,"
 FOR PENNSYLVANIA ELECTRIC COMPANY, JOHNSTOWN, PA, BY E. D'APPALONIA
 CONSULTING ENGINEERS, I.C., PITTSBURGH, PA, 1972.

DAM CLASSIFICATION

DAM SIZE: SMALL

(REF 1, TABLE 1)

HAZARD CLASSIFICATION: HIGH

(FIELD OBSERVATION)

REQUIRED SDF: $\frac{1}{2}$ PMF TO PMF

(REF 1, TABLE 3)

HYDROGRAPH PARAMETERS

	MAIN BASIN	EAST BASIN	
- LENGTH OF LONGEST WATERCOURSE (L):	1.85 MI.	0.82 MI.	(PARAMETERED ON USGS TOPO QUAD: NEW FLORENCE, PA)
- LENGTH OF LONGEST WATERCOURSE FROM DAM TO A POINT OPPOSITE BASIN CENTROID (L _{CA}):	1.00 MI.	0.38 MI.	
C _E :	1.6	1.6	(SNYDER COEFF. IS: C.O.E. ROWE 24, ALLEGHENY RIVER BASIN)
C _P :	0.45	0.45	
- SNYDER'S STANDARD LAG: $T_p = C_E (L \cdot L_{CA})^{0.3}$:	1.92 HRS	1.13 HRS	

(NOTE: HYDROGRAPH VARIABLES USED HERE ARE DEFINED IN REF. 2,
 IN SECTION ENTITLED "SNYDER SYNTHETIC UNIT HYDROGRAPH")

PROJECT DAM SAFETY INSPECTION
PENELEC RETENTION DAM
 BY DJS DATE 2-20-80 PROJ. NO. 79-303-809
 CHKD. BY DLA DATE 2-28-80 SHEET NO. 3 OF 13



RESERVOIR STORAGE CAPACITY

STORAGE VOLUMES BELOW ELEVATION 1155.0*:

<u>RESERVOIR ELEVATION</u> <u>(FT)</u>	<u>STORAGE</u> <u>(AC-FT)</u>
1133.0	0
1135.0	1.4
1140.0	4.8
1145.0	14.0
(NORMAL POOL) 1150.0	29.8
1152.0	39.0
1154.0	50.5
(LOW TOP OF DAM) 1154.9	56.9
1155.0	57.4

* VALUES TAKEN FROM STORAGE-ELEVATION CURVE; SEE FIGURE 8.

STORAGE VOLUMES ABOVE ELEVATION 1155.0:

- BETWEEN ELEVATIONS 1155.0 AND 1160.0, IT IS ASSUMED THAT THE MODIFIED PRISMOIDAL RELATIONSHIP ADEQUATELY MODELS THE RESERVOIR SURFACE AREA - STORAGE RELATIONSHIP. (REF 14, p. 15)

$$\Delta V_{1-2} = \frac{h}{3} (A_1 + A_2 + \sqrt{A_1 A_2})$$

WHERE

ΔV_{1-2} = INCREMENTAL VOLUME BETWEEN ELEVATIONS 1 & 2, IN ACRE-FT,

h = ELEVATION 1 - ELEVATION 2, IN FEET,

A_1 = SURFACE AREA AT ELEVATION 1, IN ACRES, AND

A_2 = SURFACE AREA AT ELEVATION 2, IN ACRES.

SUBJECT DAM SAFETY INSPECTION
PENELEC RETENTION DAM
 BY ZJS DATE 2-22-80 PROJ. NO. 79-303-809
 CHKD. BY DLB DATE 2-28-80 SHEET NO. 4 OF 13



ALSO, S.A. @ ELEV 1155.0 = 4.9 ACRES (FIGURE 8)

S.A. @ ELEV 1160.0 = 9.1 ACRES (PLANIMETERED ON FIG. 8)

- ASSUME SURFACE AREAS AT ELEVATIONS BETWEEN 1155.0 AND 1160.0 VARY LINEARLY.

ELEVATION - STORAGE RELATIONSHIP ABOVE ELEV. 1155.0 :

ELEVATION (FT)	SURFACE AREA (AC.)	ΔV_{1-2} (AC-FT)	TOTAL VOLUME (AC-FT)
1155.0	4.9	—	57.4 *
1156.0	5.7	5.3	62.7
1157.0	6.6	6.1	68.8
1158.0	7.4	7.0	75.8
1159.0	8.3	7.8	83.6
1160.0	9.1	8.7	92.3

* - SEE SHEET 3.

PMP CALCULATIONS

- APPROXIMATE RAINFALL INDEX = 24 INCHES
 (CORRESPONDING TO A DURATION OF 24 HOURS
 AND AN AREA OF 200 SQUARE MILES IN
 SOUTHWESTERN PENNSYLVANIA.)

(REF. 3, FIG. 1)

- DEPTH - AREA - DURATION ZONE # 7.

(REF 3, FIG. 1)

PROJECT DAM SAFETY INSPECTION
PENELEC RETENTION DAM
 BY DSS DATE 2-20-80 PROJ. NO. 79-203-809
 CHKD. BY DLO DATE 2-28-80 SHEET NO. 5 OF 13

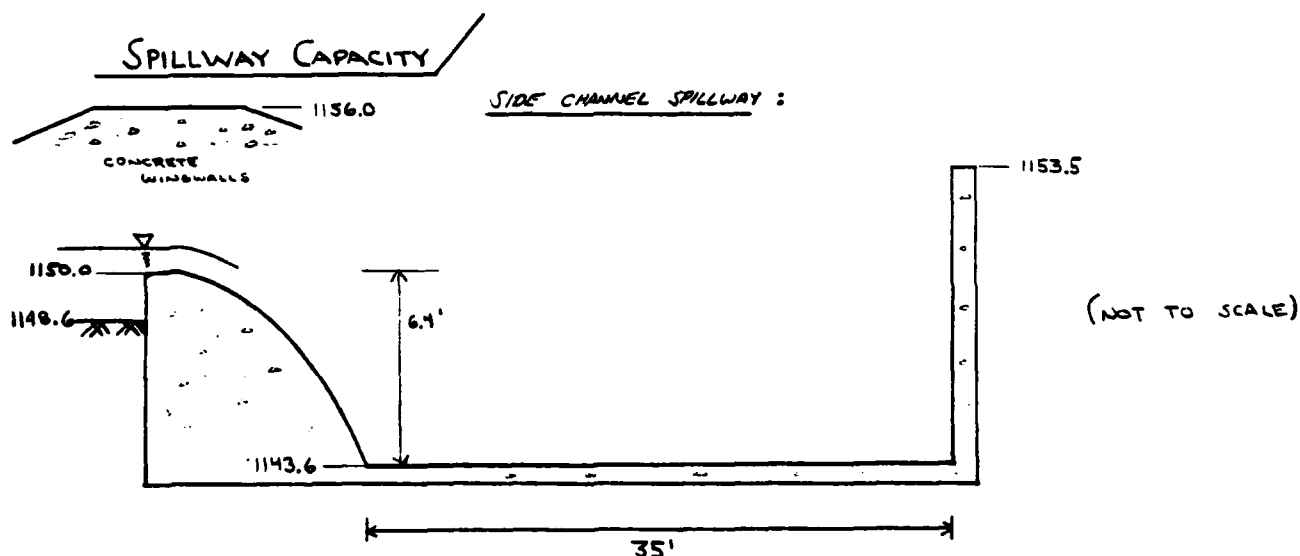
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- DRAINAGE AREA OF MAIN BASIN = 0.91 SQUARE MILES; DRAINAGE AREA OF EAST BASIN = 0.33 SQUARE MILES; ASSUME THAT DATA CORRESPONDING TO A 10 - SQUARE MILE AREA IS REPRESENTATIVE OF TOTAL BASIN AREA, 1.24 SQ MI:

DURATION (HRS)	PERCENT OF INDEX RAINFALL
6	100
12	120
24	130
48	140

- HOB BROOK FACTOR (ADJUSTMENT FOR BASIN SHAPE AND FOR THE LESSER LIKELIHOOD OF A SEVERE STORM CENTERING OVER A SMALL BASIN) FOR DRAINAGE AREA OF 1.24 SQUARE MILES IS 0.80

(REF 4, p. 48)



- BASED ON FIELD MEASUREMENTS

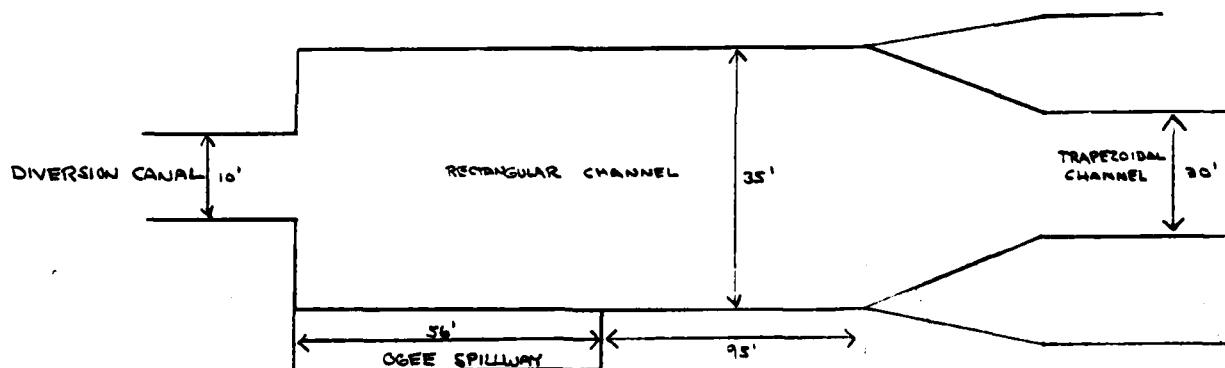
AND FIG. 6

ECT DAM SAFETY INSPECTION
PENELEC RETENTION DAM
 BY RJS DATE 2-21-80 PROJ. NO. 79-203-809
 CHKD. BY DLB DATE 2-28-80 SHEET NO. 6 OF 13

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THE SPILLWAY CONSISTS OF 56-FOOT OGEE-TYPE SIDE-CHANNEL SPILLWAY, WHICH DISCHARGES INTO A 35-FT. WIDE RECTANGULAR CHANNEL. THIS CONCRETE RECTANGULAR CHANNEL EXTENDS 95 FEET BEYOND THE DOWNSTREAM END OF THE SIDE-CHANNEL SPILLWAY. A CONCRETE TRANSITION SECTION IS THEN PROVIDED, AS THE CHANNEL SECTION BECOMES TRAPEZOIDAL AND GABION-LINED, EXTENDING ABOUT 420 FEET BEFORE DISCHARGING INTO THE NATURAL CHANNEL.

ALSO, THE DIVERSION CANAL, WHICH CONVEYS UP TO 250 CFS OF RUNOFF FROM THE EAST BASIN, DISCHARGES INTO THE RECTANGULAR CHANNEL AT A POINT JUST UPSTREAM OF THE SIDE-CHANNEL WEIR.



- NOT TO SCALE -

(FROM FIG. 7)

IN THE HEC-1 COMPUTER PROGRAM OVERTOPPING ANALYSIS, UP TO 250 CFS IS SUBTRACTED FROM ALL ORDINATES OF THE EAST BASIN OUTFLOW HYDROGRAPH, IN ORDER TO ACCOUNT FOR THE DISCHARGE CONVEYED BY THE DIVERSION CANAL, BYPASSING THE OGEE SPILLWAY.

ECT DAM SAFETY INSPECTION
PENELEC RETENTION DAM
 BY DJS DATE 2-25-80 PROJ. NO. 79-292-209
 CHKD. BY DLB DATE 2-28-80 SHEET NO. 7 OF 13



SPILLWAY CAPACITY:

- DISCHARGE OVER THE OGEE-TYPE WEIR CAN BE ESTIMATED BY THE RELATION

$$Q = CLH^{3/2} \quad (\text{REF 4, p. 373}) ,$$

WHERE

Q = WEIR DISCHARGE, IN CFS,

C = DISCHARGE COEFFICIENT,

L = LENGTH OF WEIR CREST = 56 FT, AND

H = EFFECTIVE HEAD ON WEIR CREST, IN FEET.

THE DESIGN HEAD IS 3.1 FEET, AS REPORTED IN THE "ENGINEER'S REPORT" (SEE NOTE 1), AND THE CORRESPONDING COEFFICIENT OF DISCHARGE IS 3.8. AS THE HEAD ON THE WEIR BECOMES SMALL, DISCHARGE IS REDUCED DISPROPORTIONATELY, DUE TO THE ROUGHNESS AND THE CONTACT PRESSURE BETWEEN THE WATER AND THE WEIR SURFACE. THUS, THE DISCHARGE COEFFICIENT (C) TAKES ON A LOWER VALUE THAN THAT AT DESIGN HEAD. THE OPPOSITE TENDENCY OCCURS FOR HEADS GREATER THAN THAT OF DESIGN. THEREFORE, THE DISCHARGE COEFFICIENT MUST BE MODIFIED APPROPRIATELY, ACCORDING TO FIGURE 250, REFERENCE 4.

DISCHARGE OVER THE OGEE WILL BE AFFECTED BY TAILWATER CONDITIONS AT THE HIGHER FLOWS. THEREFORE, THE DISCHARGE COEFFICIENT MUST ALSO BE MODIFIED TO ACCOUNT FOR SUBMERGENCE EFFECTS. IN ORDER TO ESTIMATE TAILWATER LEVELS CORRESPONDING TO VARIOUS OUTFLOWS, A BACKWATER CURVE WAS COMPUTED, BY USE OF THE HEC-2 WATER SURFACE PROFILES COMPUTER PROGRAM (HEC-2 WATER SURFACE PROFILES, USERS MANUAL, HYDROLOGIC ENGINEERING CENTER, U.S. ARMY CORPS OF ENGINEERS, DAVIS, CA, NOV., 1976). HEC-2 COMPUTES BACKWATER BY THE STANDARD STEP METHOD (REF 7, p. 274-280), BASED ON CHANNEL CROSS-SECTION INFORMATION. SPECIFIC CROSS-SECTION DATA

IECT DAM SAFETY INSPECTION
PENELEC RETENTION DAM
 BY ZJS DATE 2-25-80 PROJ. NO. 79-203-809
 CHKD. BY DLG DATE 2-28-80 SHEET NO. 8 OF 13



USED HERE IS GIVEN ON SHEET 13 (SEE FIG. 3). COMPUTATIONS WERE INITIATED AT A SECTION (SECTION 1, SHEET 13) LOCATED ABOUT 135 FEET DOWNSTREAM OF THE OGEE STRUCTURE, AT THE CHANNEL TRANSITION. CRITICAL DEPTH WAS ASSUMED HERE, DUE TO THE TRANSITION AND THE BREAK IN CHANNEL SLOPE (0.1 % TO 7.0 % SLOPE). CALCULATIONS PROCEEDED UPSTREAM, TO A SECTION LOCATED JUST DOWNSTREAM OF THE OGEE. WATER SURFACE ELEVATIONS AT THIS SECTION (SECTION 3) WERE ASSUMED TO BE APPLICABLE FOR THE ENTIRE LENGTH OF THE OGEE.

TAILWATER RATING CURVE:

ELEVATION * (FT)	DISCHARGE (CFS)
1146.8	500
1148.3	1000
1149.4	1500
1150.2	2000
1150.7	2500
1151.1	3000
1151.4	3500
1152.1	4000
1153.1	5000
1153.7	6000
1154.5	7000

* WATER SURFACE ELEVATION AT SECTION 3 ; SEE SUMMARY INPUT /OUTPUT SHEETS, SHEET B . CHANNEL INVERT = 1143.6 FT.

PROJECT DAM SAFETY INSPECTION
PERMANENT RETENTION DAM
 BY DTS DATE 2-25-80 PROJ. NO. 79-293-309
 CHKD. BY DLB DATE 2-28-80 SHEET NO. 9 OF 13



ALSO TAKEN INTO ACCOUNT WITH THE TAILWATER IS THE OUTFLOW OF UP TO 250 CFS FROM THE EAST VALLEY DIVERSION CANAL. A DISCHARGE OF 250 CFS IS ASSUMED TO OCCUR IN THE DIVERSION CANAL AT ALL RESERVOIR ELEVATIONS, TO BE CONSERVATIVE. APPROACH LOSSES AT THE Ogee WERE ASSUMED TO BE INSIGNIFICANT.

SPILLWAY RATING TABLE:

RESERVOIR ELEVATION (FT)	H (FT)	$1/H_0$ ①	C/C_0 ②	C ③	INITIAL OUTFLOW ESTIMATE (CFS)	POTENTIAL CHANNEL DISCHARGE (CFS)	ESTIMATED TW DEPTH (FT)	h_d (FT)	h_d/H	C_s/C ④	C_s ⑤	Q ⑥ (CFS)
1150.0	—	—	—	—	—	—	—	—	—	—	—	0
1151.0	1.0	0.32	0.88	3.34	190	440	2.8	4.6	4.60	1.0	3.34	190
1152.0	2.0	0.65	0.95	3.61	570	830	4.2	4.2	2.10	1.0	3.61	570
1153.0	3.0	0.97	0.99	3.76	1090	1340	5.4	4.0	1.33	1.0	3.76	1090
1154.0	4.0	1.29	1.04	3.95	1770	2020	6.6	3.8	0.95	1.0	3.95	1770
1154.9 (LOW TOP OF DAM)	4.9	1.58	1.07	4.00	2430	2680	7.2	4.1	0.84	1.0	4.00	2430
1155.0	5.0	1.61	1.07	4.00	2500	2750	7.3	4.1	0.82	1.0	4.00	2500
1156.0	6.0	1.94	1.07	4.00	3290	3540	7.9	4.5	0.75	1.0	4.00	3290
1157.0	7.0	2.26	1.07	4.00	4150	4400	8.9	4.5	0.64	0.99	3.96	4110
1158.0	8.0	2.59	1.07	4.00	5070	5320	9.7	4.7	0.59	0.98	3.92	4970
1159.0	9.0	2.90	1.07	4.00	6050	6300	10.3	5.1	0.57	0.98	3.92	5930
1160.0	10.0	3.23	1.07	4.00	7080	7330	11.2	5.2	0.52	0.98	3.92	6940

① $H_0 = 3.1$ FT (DESIGN HEAD)

② C/C_0 : FROM REF 4, FIG 250, P. 378

③ $C_0 = 3.8$; $C = C_0 \times C/C_0$

④ $Q = CLH^{3/2}$, $L = 56$ FT

⑤ POTENTIAL CHANNEL DISCHARGE =

INITIAL OUTFLOW ESTIMATE + 350 CFS (E. VALLEY BY-PASS)

⑥ INTERPOLATED/EXTRAPOLATED FROM TAILWATER RATING

TABLE, CHANNEL INVERT = 1143.6 FT.

⑦ $h_d = \text{RESERVOIR ELEV} - \text{TW DEPTH} - 1143.6$ (SEE REF 4, FIG 254)

⑧ FROM REF 4, FIG 254, P. 382

⑨ $C_s = C \times C/C$

⑩ $Q = C_s L H^{3/2}$, $L = 56$ FT

PROJECT DAM SAFETY INSPECTION
PEVELEC RETENTION DAM
 BY DJS DATE 2-21-80 PROJ. NO. 79-203-809
 CHKD. BY DLG DATE 2-28-80 SHEET NO. 10 OF 13



EMBANKMENT RATING CURVE

- ASSUME THAT THE EMBANKMENT BEHAVES ESSENTIALLY AS A
 BROAD-CRESTED WEIR WHEN OVERTOPPING OCCURS. THUS, DISCHARGE CAN BE
 ESTIMATED BY THE RELATIONSHIP

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

WHERE

Q = DISCHARGE OVER THE EMBANKMENT, IN CFS,
 L = LENGTH OF EMBANKMENT OVERTOPPED, IN FEET,
 H = HEAD, IN FEET; IN THIS CASE IT IS THE
 AVERAGE "FLOW-AREA" WEIGHTED HEAD ABOVE THE
 CREST, WITH THE LOW TOP OF DAM AS THE DATUM;
 C = COEFFICIENT OF DISCHARGE, DEPENDENT ON THE
 HEAD AND THE WEIR BREADTH.

LENGTH OF EMBANKMENT INUNDATED VS. RESERVOIR ELEVATION:

RESERVOIR ELEVATION (FT)	EMBANKMENT LENGTH (FT)
(LOW TOP OF DAM) 1134.9	0
1135.8	15
1156.0	100
1156.1	280
1156.2	450
1156.5	465
1157.0	485
1158.0	530
1158.6	550
1159.0	560
1160.0	575

(BASED ON FIELD MEASUREMENTS)

PROJECT DAM SAFETY INSPECTION
PENELEC RETENTION DAM
 BY DJS DATE 2-21-80 PROJ. NO. 79-203-809
 CHKD. BY DLG DATE 2-26-80 SHEET NO. 11 OF 13



ASSUME THAT INCREMENTAL DISCHARGES (FOR SUCCESSIVE RESERVOIR ELEVATIONS) OVER THE EMBANKMENT ARE APPROXIMATELY TRAPEZOIDAL IN CROSS-SECTIONAL FLOW AREA. THEN ANY INCREMENTAL AREA OF FLOW, A_i , CAN BE ESTIMATED AS $H_i \times [(L_1 + L_2)/2]$, WHERE L_1 = LENGTH OF EMBANKMENT AT HIGHER ELEVATION, L_2 = LENGTH OF EMBANKMENT AT LOWER ELEVATION, AND H_i = DIFFERENCE IN ELEVATIONS. THE AVERAGE FLOW-AREA WEIGHTED HEAD WILL THUS BE

$$H_w = (A_t / L_1), \text{ WHERE } A_t = \text{TOTAL FLOW AREA.}$$

EMBANKMENT RATING TABLE:

RESERVOIR ELEVATION (FT)	L_1 (FT)	L_2 (FT)	INCREMENTAL HEAD, H_i (FT)	① INCREMENTAL FLOW AREA, A_i (FT ²)	TOTAL FLOW AREA, A_t (FT ²)	② WEIGHTED HEAD, H_w (FT)	③ $\frac{H_w}{L}$	④ C	⑤ Q (CFS)
1154.9	0	-	0	0	0	0	-	-	0
1155.8	15	0	0.9	7	7	0.5	0.03	3.02	20
1156.0	100	15	0.2	12	19	0.2	0.01	2.97	30
1156.1	280	100	0.1	19	38	0.1	0.01	2.93	30
1156.2	450	280	0.1	37	75	0.2	0.01	2.97	120
1156.5	465	450	0.3	137	212	0.5	0.03	3.02	500
1157.0	485	465	0.5	238	450	0.9	0.06	3.03	1250
1158.0	530	485	1.0	508	958	1.8	0.12	3.04	3890
1159.0	560	530	1.0	545	1503	2.7	0.18	3.07	7630
1160.0	575	560	1.0	568	2071	3.6	0.24	3.08	12,100

① $A_i = H_i \left[\frac{L_1 + L_2}{2} \right]$

② $H_w = A_t / L_1$

③ L = BREADTH OF CREST = 15' (FIELD MEASURED)

④ $C = f(H_w, L)$; FROM REF 12, FIG. 24.

⑤ $Q = CL H_w^{3/2}$

PROJECT DAM SAFETY INSPECTION

PEVELEC RETENTION DAM

BY JSJ DATE 2-25-80 PROJ. NO. 79-303-809

CHKD. BY DLB DATE 2-28-80 SHEET NO. 12 OF 13



Engineers • Geologists • Planners
Environmental Specialists

TOTAL FACILITY RATING TABLE

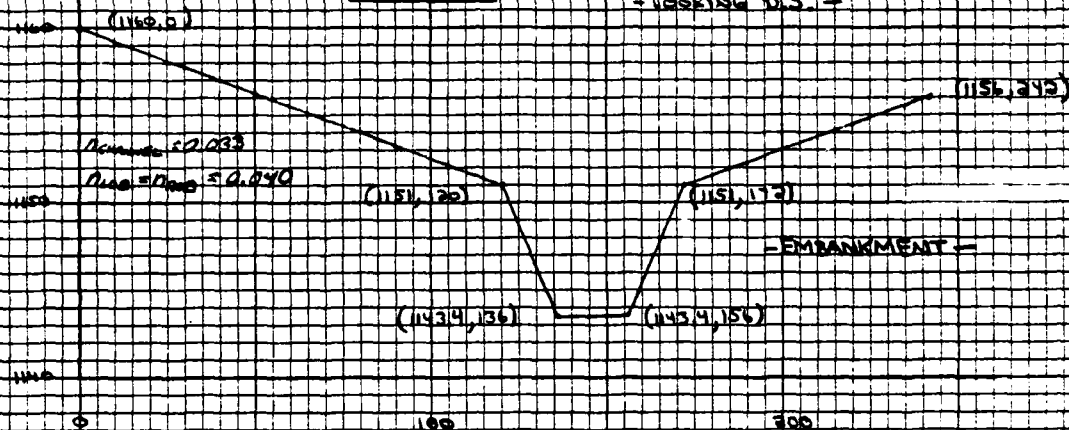
	<u>RESERVOIR ELEVATION</u>	<u>Q_{SPILLWAY}</u>	<u>Q_{EMBANKMENT}</u>	<u>Q_{TOTAL}</u>
	1150.0	0	-	0
	1151.0	190	-	190
	1152.0	570	-	570
	1153.0	1090	-	1090
	1154.0	1770	-	1770
(LOW TOP OF DAM)	1154.9	2430	0	2430
	1155.0	2500 *	0	2500
	1155.8	3130	20	3150
	1156.0	3290	30	3320
	1156.2	3450 *	120	3570
	1156.5	3700 *	500	4200
	1157.0	4110	1250	5360
	1158.0	4970	3890	8860
	1159.0	5930	7630	13,560
	1160.0	6940	12,100	19,040

* - BY LINEAR INTERPOLATION

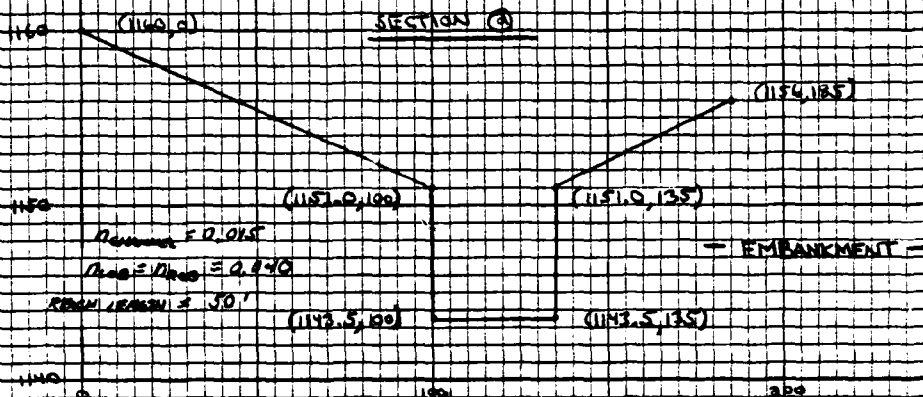
CROSS SECTIONS FOR HEL-2 BACKWATER COMPUTATION:

SECTION ①

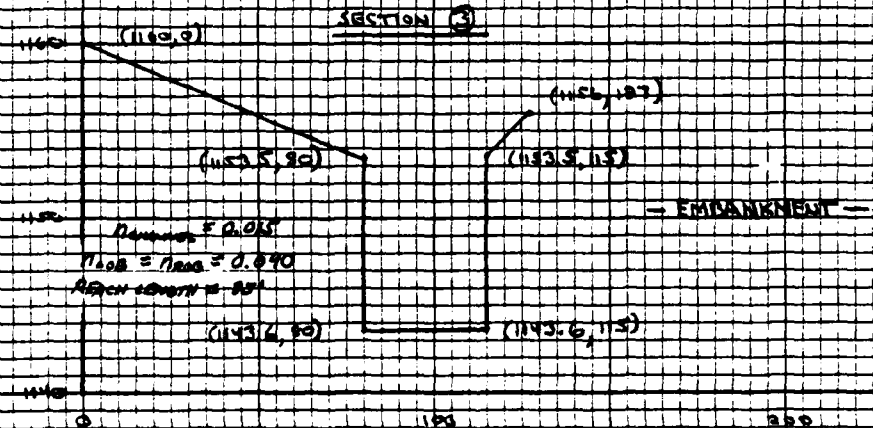
- LOOKING D.S. -



SECTION ②



SECTION ③



(SECTIONS BASED ON DETAILED PLAN OF SPILLWAY, FIG. 3)

DAM SAFETY INSPECTION

PENELEC RETENTION DAM

BY JES

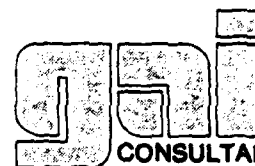
DATE 3-4-80

PROJ. NO. 79-203-809

CHKD. BY DLB

DATE 3-9-80

SHEET NO. A OF C



CONSULTANTS, INC.

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HEC-2 TAILWATER COMPUTATION

SUMMARY INPUT/OUTPUT SHEETS

[illegible]

SUBJECT

DAM SAFETY INSPECTION

PENELEC RETENTION DAM

BY DJSDATE 3-4-80PROJ. NO. 79-203-809CHKD. BY DLBDATE 3-4-80SHEET NO. B OF GEngineers • Geologists • Planners
Environmental Specialists

DISCHARGE ELEVATION

SECTION	XLCH	ELTHD	ELLC	ELMIN	U	CHSEL	CRAMS	EG	10X+5	VCH	AREA
* 1.000	0.0	0.0	0.0	1143.40	500.00	1145.84	1145.84	1146.87	133.23	8.13	61.
* 1.000	0.0	0.0	0.0	1143.40	1000.00	1147.10	1147.10	1148.57	120.14	9.72	102.
* 1.000	0.0	0.0	0.0	1143.40	1500.00	1148.10	1148.10	1149.87	111.66	10.66	140.
* 1.000	0.0	0.0	0.0	1143.40	2000.00	1148.90	1148.90	1150.96	110.40	11.53	173.
* 1.000	0.0	0.0	0.0	1143.40	2500.00	1149.64	1149.64	1151.91	105.83	12.09	206.
* 1.000	0.0	0.0	0.0	1143.40	3000.00	1150.32	1150.32	1152.76	102.17	12.55	239.
* 1.000	0.0	0.0	0.0	1143.40	3500.00	1150.83	1150.83	1153.54	104.73	13.20	265.
* 1.000	0.0	0.0	0.0	1143.40	4000.00	1151.49	1151.49	1154.26	92.87	13.35	302.
* 1.000	0.0	0.0	0.0	1143.40	5000.00	1152.79	1152.79	1155.47	70.04	13.29	410.
* 1.000	0.0	0.0	0.0	1143.40	6000.00	1153.82	1153.82	1156.42	59.07	13.36	528.
* 1.000	0.0	0.0	0.0	1143.40	7000.00	1154.60	1154.60	1157.22	54.52	13.64	637.
* 2.000	50.00	0.0	0.0	1143.50	500.00	1146.80	0.0	1147.09	4.89	4.33	115.
* 2.000	50.00	0.0	0.0	1143.50	1000.00	1148.28	0.0	1148.43	6.25	5.98	167.
* 2.000	50.00	0.0	0.0	1143.50	1500.00	1149.30	0.0	1150.15	7.81	7.39	203.
* 2.000	50.00	0.0	0.0	1143.50	2000.00	1150.08	0.0	1151.25	9.56	8.69	230.
* 2.000	50.00	0.0	0.0	1143.50	2500.00	1150.62	0.0	1152.18	11.81	10.04	249.
* 2.000	50.00	0.0	0.0	1143.50	3000.00	1150.93	0.0	1152.99	15.01	11.54	259.
* 2.000	50.00	0.0	0.0	1143.50	3500.00	1150.99	0.0	1153.76	19.92	13.45	262.
* 2.000	50.00	0.0	0.0	1143.50	4000.00	1151.40	1150.85	1154.65	21.77	14.46	270.
* 2.000	50.00	0.0	0.0	1143.50	5000.00	1152.39	1152.39	1156.33	22.70	15.97	331.
* 2.000	50.00	0.0	0.0	1143.50	6000.00	1153.89	1153.89	1157.75	18.52	16.00	451.
* 2.000	50.00	0.0	0.0	1143.50	7000.00	1155.06	1155.06	1158.92	16.60	16.27	578.
* 3.000	85.00	0.0	0.0	1143.60	500.00	1146.83	0.0	1147.14	5.20	4.41	133.
* 3.000	85.00	0.0	0.0	1143.60	1000.00	1148.32	0.0	1148.89	6.45	6.04	165.
* 3.000	85.00	0.0	0.0	1143.60	1500.00	1149.36	0.0	1150.22	7.95	7.43	201.
* 3.000	85.00	0.0	0.0	1143.60	2000.00	1150.18	0.0	1151.33	9.60	8.70	229.
* 3.000	85.00	0.0	0.0	1143.60	2500.00	1150.72	0.0	1152.28	11.79	10.03	249.
* 3.000	85.00	0.0	0.0	1143.60	3000.00	1151.11	0.0	1153.13	14.48	11.40	263.
* 3.000	85.00	0.0	0.0	1143.60	3500.00	1151.43	0.0	1153.96	17.47	12.76	276.
* 3.000	85.00	0.0	0.0	1143.60	4000.00	1152.10	0.0	1154.90	17.96	13.43	297.
* 3.000	85.00	0.0	0.0	1143.60	5000.00	1153.06	0.0	1156.60	20.63	15.09	331.
* 3.000	85.00	0.0	0.0	1143.60	6000.00	1153.71	1153.23	1156.17	24.32	16.95	354.
* 3.000	85.00	0.0	0.0	1143.60	7000.00	1154.51	1154.51	1159.71	25.68	18.31	380.

SECTION
IMMEDIATELY
DOWNSTREAM
OF
Ogee WEIR

* CRITICAL DEPTH ASSUMED.

SUBJECT DAM SAFETY INSPECTION

PENELEC RETENTION DAM

BY 2TS DATE 2-4-80 PROJ. NO. 79-203-809

CHKD. BY DLB DATE 3-4-80 SHEET NO. C OF G



OVERTOPPING ANALYSIS:

DAM SAFETY INSPECTION
PENELEC RETENTION DAM *** OVERTOPPING ANALYSIS ***
10-MINUTE TIME STEP AND 48-HOUR DURATION

JOB SPECIFICATION
JHR 0 NMIN 10 JDAY 0 JNIN 0 JNTH 0 JNLT 0 JNSTAN 0
JOPER 5 JNPT 0 JNPT 0 JNPT 0 JNPT 0 JNPT 0
JNPT 0 JNPT 0 JNPT 0 JNPT 0 JNPT 0 JNPT 0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NHTIO= 5 LHTIO= 1
NPLAN= .50 .60 .70 .80 1.00

SUB-AREA RUNOFF COMPUTATION

EAST BASIN RUNOFF HYDROGRAPH

1STAG 1CUMP 1ECUM 1TAVE 1JPLJ 1JPHF 1NAME 1STAGE 1AUTU
1 0 0 0 0 0 1 0 0

HYDROGRAPH DATA
1HYD 1UNG 1AREA 1SNAP 1TNSDA 1THSPC 1RATIO 1SMUN 1ISAME 1LOCAL
1 1 .33 0.00 1.24 0.00 0.000 0 1 0

PRECIP DATA
SPPF 0.00 PHS 24.00 R6 102.00 R12 120.00 R24 130.00 R48 140.00 R72 0.00 R96 0.00
TNSPC COMPUTED BY THE PROGRAM IS .800

INITIAL AND CONSTANT
RAINFALL LOSSES: .000

LOSS DATA
LROFI STRKR ULTRN HTIOL ERAIN STRKS RTIUK SIRTIL CNSTL ALSHX RTIMP
0 0.00 0.00 1.00 0.00 0.00 0.00 1.00 0.00 0.00 0.00 0.00

UNIT HYDROGRAPH DATA
TP= 1.13 CPE= .45 NTA= 0 BASE FLOW PARAMETERS: COE

RECESSION DATA
SINTIO= -1.50 QRCSE= -2.05 NTHUNE 2.00
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNIDEK CP AND TP ARE TC= 7.09 AND K=10.92 INTERVALS

UNIT HYDROGRAPH 62 END-OF-PERIOD ORDINATES, LAG= 1.14 HOURS, CPE= .45 VOLUME 1.00
4. 16. 32. 48. 64. 80. 96. 112. 128. 144. 160. 176. 192. 208. 224. 240. 256. 272. 288. 304. 320. 336. 352. 368. 384. 400. 416. 432. 448. 464. 480. 496. 512. 528. 544. 560. 576. 592. 608. 624. 640. 656. 672. 688. 704. 720. 736. 752. 768. 784. 800. 816. 832. 848. 864. 880. 896. 912. 928. 944. 960. 976. 992. 1008. 1024. 1040. 1056. 1072. 1088. 1104. 1120. 1136. 1152. 1168. 1184. 1200. 1216. 1232. 1248. 1264. 1280. 1296. 1312. 1328. 1344. 1360. 1376. 1392. 1408. 1424. 1440. 1456. 1472. 1488. 1504. 1520. 1536. 1552. 1568. 1584. 1600. 1616. 1632. 1648. 1664. 1680. 1696. 1712. 1728. 1744. 1760. 1776. 1792. 1808. 1824. 1840. 1856. 1872. 1888. 1904. 1920. 1936. 1952. 1968. 1984. 2000. 2016. 2032. 2048. 2064. 2080. 2096. 2112. 2128. 2144. 2160. 2176. 2192. 2208. 2224. 2240. 2256. 2272. 2288. 2304. 2320. 2336. 2352. 2368. 2384. 2400. 2416. 2432. 2448. 2464. 2480. 2496. 2512. 2528. 2544. 2560. 2576. 2592. 2608. 2624. 2640. 2656. 2672. 2688. 2704. 2720. 2736. 2752. 2768. 2784. 2800. 2816. 2832. 2848. 2864. 2880. 2896. 2912. 2928. 2944. 2960. 2976. 2992. 3008. 3024. 3040. 3056. 3072. 3088. 3104. 3120. 3136. 3152. 3168. 3184. 3200. 3216. 3232. 3248. 3264. 3280. 3296. 3312. 3328. 3344. 3360. 3376. 3392. 3408. 3424. 3440. 3456. 3472. 3488. 3504. 3520. 3536. 3552. 3568. 3584. 3600. 3616. 3632. 3648. 3664. 3680. 3696. 3712. 3728. 3744. 3760. 3776. 3792. 3808. 3824. 3840. 3856. 3872. 3888. 3904. 3920. 3936. 3952. 3968. 3984. 4000. 4016. 4032. 4048. 4064. 4080. 4096. 4112. 4128. 4144. 4160. 4176. 4192. 4208. 4224. 4240. 4256. 4272. 4288. 4304. 4320. 4336. 4352. 4368. 4384. 4400. 4416. 4432. 4448. 4464. 4480. 4496. 4512. 4528. 4544. 4560. 4576. 4592. 4608. 4624. 4640. 4656. 4672. 4688. 4704. 4720. 4736. 4752. 4768. 4784. 4800. 4816. 4832. 4848. 4864. 4880. 4896. 4912. 4928. 4944. 4960. 4976. 4992. 5008. 5024. 5040. 5056. 5072. 5088. 5104. 5120. 5136. 5152. 5168. 5184. 5200. 5216. 5232. 5248. 5264. 5280. 5296. 5312. 5328. 5344. 5360. 5376. 5392. 5408. 5424. 5440. 5456. 5472. 5488. 5504. 5520. 5536. 5552. 5568. 5584. 5600. 5616. 5632. 5648. 5664. 5680. 5696. 5712. 5728. 5744. 5760. 5776. 5792. 5808. 5824. 5840. 5856. 5872. 5888. 5904. 5920. 5936. 5952. 5968. 5984. 6000. 6016. 6032. 6048. 6064. 6080. 6096. 6112. 6128. 6144. 6160. 6176. 6192. 6208. 6224. 6240. 6256. 6272. 6288. 6304. 6320. 6336. 6352. 6368. 6384. 6400. 6416. 6432. 6448. 6464. 6480. 6496. 6512. 6528. 6544. 6560. 6576. 6592. 6608. 6624. 6640. 6656. 6672. 6688. 6704. 6720. 6736. 6752. 6768. 6784. 6800. 6816. 6832. 6848. 6864. 6880. 6896. 6912. 6928. 6944. 6960. 6976. 6992. 7008. 7024. 7040. 7056. 7072. 7088. 7104. 7120. 7136. 7152. 7168. 7184. 7200. 7216. 7232. 7248. 7264. 7280. 7296. 7312. 7328. 7344. 7360. 7376. 7392. 7408. 7424. 7440. 7456. 7472. 7488. 7504. 7520. 7536. 7552. 7568. 7584. 7600. 7616. 7632. 7648. 7664. 7680. 7696. 7712. 7728. 7744. 7760. 7776. 7792. 7808. 7824. 7840. 7856. 7872. 7888. 7904. 7920. 7936. 7952. 7968. 7984. 8000. 8016. 8032. 8048. 8064. 8080. 8096. 8112. 8128. 8144. 8160. 8176. 8192. 8208. 8224. 8240. 8256. 8272. 8288. 8304. 8320. 8336. 8352. 8368. 8384. 8400. 8416. 8432. 8448. 8464. 8480. 8496. 8512. 8528. 8544. 8560. 8576. 8592. 8608. 8624. 8640. 8656. 8672. 8688. 8704. 8720. 8736. 8752. 8768. 8784. 8800. 8816. 8832. 8848. 8864. 8880. 8896. 8912. 8928. 8944. 8960. 8976. 8992. 9008. 9024. 9040. 9056. 9072. 9088. 9104. 9120. 9136. 9152. 9168. 9184. 9200. 9216. 9232. 9248. 9264. 9280. 9296. 9312. 9328. 9344. 9360. 9376. 9392. 9408. 9424. 9440. 9456. 9472. 9488. 9504. 9520. 9536. 9552. 9568. 9584. 9600. 9616. 9632. 9648. 9664. 9680. 9696. 9712. 9728. 9744. 9760. 9776. 9792. 9808. 9824. 9840. 9856. 9872. 9888. 9904. 9920. 9936. 9952. 9968. 9984. 10000.

SUBJECT DAM SAFETY INSPECTION
PENELEC RETENTION DAM
 BY DJS DATE 3-4-80 PROJ. NO. 79-203-809
 CHKD. BY DLB DATE 3-4-80 SHEET NO. D OF G



U
 MU.DA HR.MM PERIOD MAIN EALS LUSS END-UP-PERIOD FLUM
 CUMP U MU.DA HR.MM PERIOD MAIN EALS LUSS CUMP U
 SUM 20.88 24.46 2.42 30454.
 (683.3) (621.3) (61.3) (802.36)

EAST BASIN RUNOFF HYDROGRAPH:

PEAK 6-HOUR 24-HOUR 72-HOUR TOTAL VOLUME
 898. 205. 106. 30432.
 CFS 16. 6. 3. 802.
 CMS 16.36 23.14 23.83 23.83
 INCHES 415.45 587.69 605.25 605.25
 MM 288. 407. 419. 419.
 AC-FT 355. 502. 517. 517.
 THOUS CU M

(PMF)

HYDROGRAPH ROUTING

REDUCE EAST BASIN OUTFLOW BY UP TO 250 CFS

ISTAU	ICOMP	IEGUN	ITAPE	UPLI	JPRT	INAME	ISTAGE	IAUTO
1	1	0	0	0	0	1	0	0
ROUTING DATA								
GLUSS	CLUSS	AVG	AKES	ISAME	IUPT	IPMP	LSTR	
250.0	0.000	0.00	0	1	0	0	0	
INSTPS	INSTDL	LAG	AKSKK	X	TSK	STURA	ISPRAT	
1	0	0	0.000	0.000	0.000	-1.	0	

EAST BASIN OUTFLOW HYDROGRAPH;

DISCHARGE REDUCED TO ACCOUNT FOR DIVERSION CANAL:

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
648.	330.	83.	42.	12000.
16.	9.	2.	1.	390.
	9.31	9.40	9.40	9.40
	230.45	230.67	230.67	230.67
	164.	165.	165.	165.
	202.	204.	204.	204.

(PMF)

PROJECT

DAM SAFETY INSPECTION

PENELEC RETENTION DAM

BY DJS

DATE 7-4-80

PROJ. NO. 79-203-809

CHKD. BY DLB

DATE 3-4-80

SHEET NO. E OF G



CONSULTANTS, INC.

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SUB-AREA RUNOFF COMPUTATION

MAIN BASIN RESERVOIR INFLOW HYDROGRAPH

ISTAU ICUMP IECUN IIAPE JPLI JPKI INAME ISTAGE IAUTU
DAM 0 0 0 0 0 0 1 0 0

HYDROGRAPH DATA
INFLUG IUNG IANEA SNAP TMSDA TRNSPC HALLU ISRUN ISAME LOCAL
1 1 .91 0.00 1.24 0.00 0.000 0 1 0

PRECIP DATA
SP'E PMS H6 H12 H24 K48 K72 K96
0.00 24.00 102.00 120.00 130.00 140.00 0.00 0.00

TRNSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA
LROUPT STRAN ULINK RTIDL ERAIN STKAS RTIOK STRTL CNSTL ALSMX RTIMP
0 0.00 0.00 1.00 0.00 0.00 1.00 1.00 .05 0.00 0.00

UNIT HYDROGRAPH DATA
TP= 1.92 CP= .45 RTIA= 0

NECESSATION DATA
STNG= -1.50 GRCSN= -.05 RTIOM= 2.00
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC=12.12 AND H=10.18 INTERVALS

UNIT HYDROGRAPH100 END-OF-PERIOD ORDINATES, LAGE 1.93 HOURS, CP= .45 VOL= .99

3.	12.	25.	40.	55.	74.	93.	109.	123.	133.
139.	141.	138.	130.	123.	117.	111.	105.	99.	94.
89.	84.	79.	75.	71.	67.	64.	60.	57.	54.
51.	48.	46.	43.	41.	39.	37.	35.	33.	31.
30.	28.	26.	25.	24.	22.	21.	20.	19.	18.
17.	16.	15.	14.	13.	12.	11.	10.	9.	8.
6.	5.	4.	3.	2.	1.	0.	0.	0.	0.
3.	2.	1.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

END-OF-PERIOD FLOW
MU.DA HR.MN PERIOD RAIN EXCS LOSS CUMP U MU.DA HR.MN PERIOD RAIN EXCS LOSS CUMP U
SUM 26.88 24.46 2.42 78640.
(0.83.11 0.21.11 01.11 226.88)

MAIN BASIN RESERVOIR INFLOW HYDROGRAPH:

PEAK
1001.
53.
CFS
CHS
INCHES
MM
AC-FT
THOUS CU M

TOTAL VOLUME
78450.
2221.
22.28
565.82
1081.
1333.

(PMF)

PENELEC RETENTION DAM

CHKD. BY DLB

PROJ. NO. 79-203-809

SHEET NO. F OF G



**Engineers • Geologists • Planners
Environmental Specialists**

[illegible]

COMBINE AND ENHANCE

COMBINE EAST BASIN OUTFLOW HYDROGRAPH WITH MAIN BASIN INFLOW HYDROGRAPH

ISTAG	ICOMP	TECUN	ITAVE	JPLT	JPKT	INAME	ISTAGE	IAUTO
1	2	0	0	0	0	1	0	0

SUM OF EAST BASIN
OUTFLOW HYDROGRAPH
AND MAIN BASIN
INFLOW HYDROGRAPH:

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL	VOLUME
CFS	2425.	1727.	613.	314.	-	90451.
CMS	69.	49.	17.	9.	-	2561.
INCHES		12.96	10.39	10.05	-	10.05
		329.16	467.02	470.75	-	470.75
AC-FT		857.	1215.	1246.	-	1246.
THOUS CU M		1057.	1499.	1537.	-	1537.

1. The first group of students, consisting of 10 students, was assigned to the control group. They were given the standard curriculum and no additional resources.

2. The second group of students, consisting of 10 students, was assigned to the experimental group. They were given the standard curriculum and additional resources, including a textbook and a workbook.

3. The third group of students, consisting of 10 students, was assigned to the experimental group. They were given the standard curriculum and additional resources, including a textbook and a workbook.

4. The fourth group of students, consisting of 10 students, was assigned to the experimental group. They were given the standard curriculum and additional resources, including a textbook and a workbook.

5. The fifth group of students, consisting of 10 students, was assigned to the experimental group. They were given the standard curriculum and additional resources, including a textbook and a workbook.

6. The sixth group of students, consisting of 10 students, was assigned to the experimental group. They were given the standard curriculum and additional resources, including a textbook and a workbook.

7. The seventh group of students, consisting of 10 students, was assigned to the experimental group. They were given the standard curriculum and additional resources, including a textbook and a workbook.

8. The eighth group of students, consisting of 10 students, was assigned to the experimental group. They were given the standard curriculum and additional resources, including a textbook and a workbook.

9. The ninth group of students, consisting of 10 students, was assigned to the experimental group. They were given the standard curriculum and additional resources, including a textbook and a workbook.

10. The tenth group of students, consisting of 10 students, was assigned to the experimental group. They were given the standard curriculum and additional resources, including a textbook and a workbook.

HYDROGRAPH ROUTING

FOUR TOTAL HYDROGRAPH THROUGH MAIN RESERVOIR

ISTAU	ICOMP	IICON	ITAPE	JPL3	JPKT	INAME	ISTAGE	LAUTO
				"	"	"	"	"

ROUTING DATA

CLASS	AVG
-------	-----

—

AC 0456K

0

1154	3.00
1155	9.00

2011 00:00

1770 1770

19040

三

25.

1145. 1

1100.

1. The first group of people who are not in the labor force are those who are not in the labor force for any reason. This group is the largest and is made up of people who are not in the labor force for any reason.

EXPENSE

;

...

1150 73401

CONFIDENTIAL

DAM SAFETY INSPECTION

PENELEC RETENTION DAM

BY JIS

DATE _____

3-4-80

PROJ. NO.

79-203 - 809

CHKD. BY DLB

DATE _____

3-4-80

SHEET NO.

On

G



CONSULTANTS, INC.

**Engineers • Geologists • Planners
Environmental Specialists**

RESERVOIR OUTFLOW HYDROGRAPH:

PEAK OUTFLOW IS 2422. AT TIME 41.50 HOURS

	PEAR	6-HOOK	24-HOOK	72-HOOK	TOTAL	VOLUME
CFS	2424.	1727.	609.	305.	87700.	
CMS	69.	49.	17.	9.	2435.	
INCHES		12.95	18.29	18.29		
MM		328.99	464.35	464.52	464.52	
AC-FT		856.	1208.	1209.	1209.	
THOUS CU M		1056.	1491.	1491.	1491.	

(PMF)

SUMMARY OF DAM SAFETY ANALYSIS

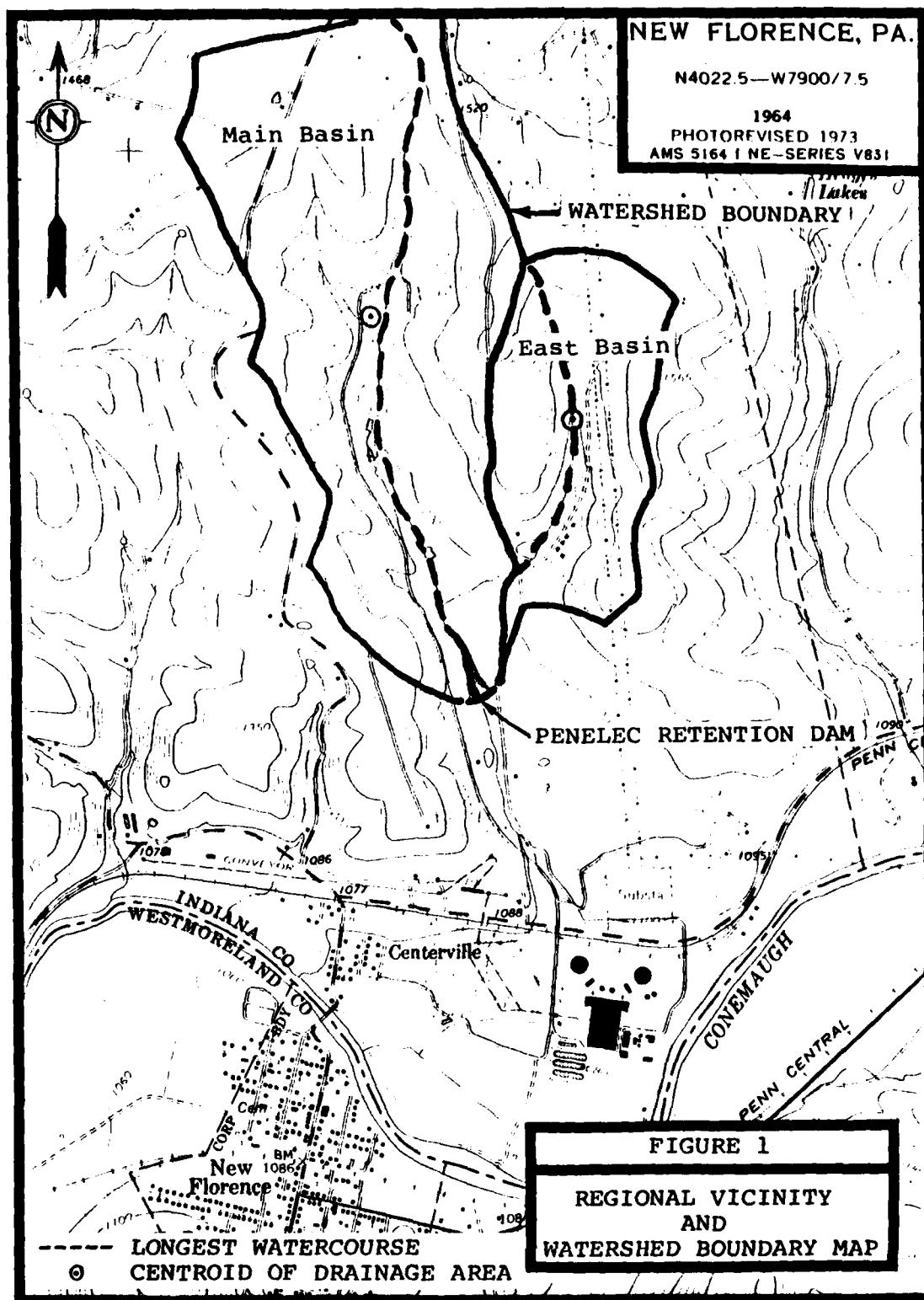
RATIO OF FPM	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	1152.99	0.00	45.	1085.	0.00	41.50	0.00
.60	1153.39	0.00	47.	1354.	0.00	41.50	0.00
.70	1153.78	0.00	49.	1621.	0.00	41.50	0.00
.80	1154.16	0.00	52.	1887.	0.00	41.50	0.00
.90	1154.54	0.00	57.	2432.	0.00	41.50	0.00
	ELEVATION	INITIAL VALUE	SPILLWAY CHEST	TUP OF DAM			
	STORAGE	1153.00	1150.00	1154.90			
	OUTFLOW	0.	30.	57.			
		0.	0.	2430.			

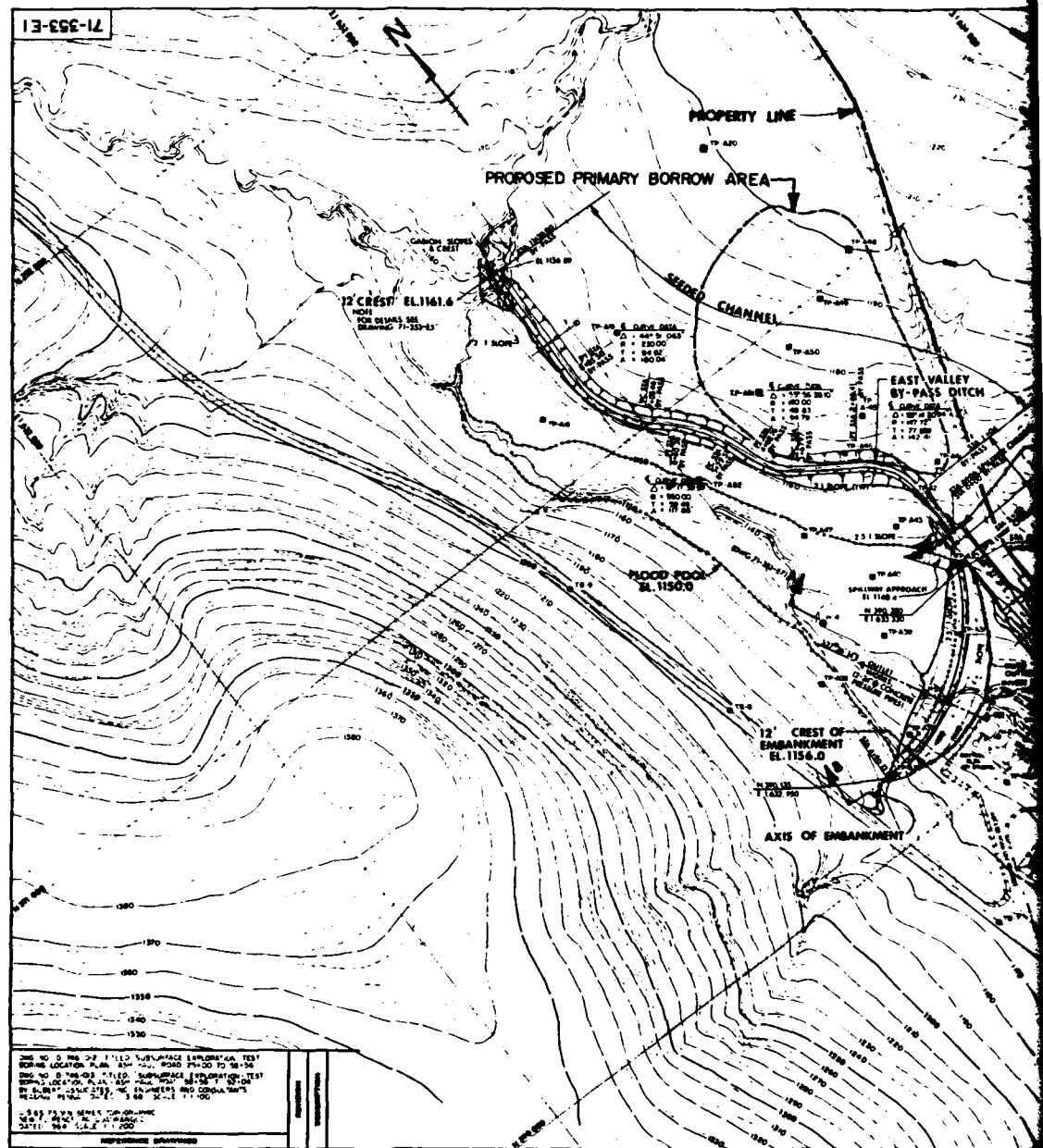
APPENDIX E

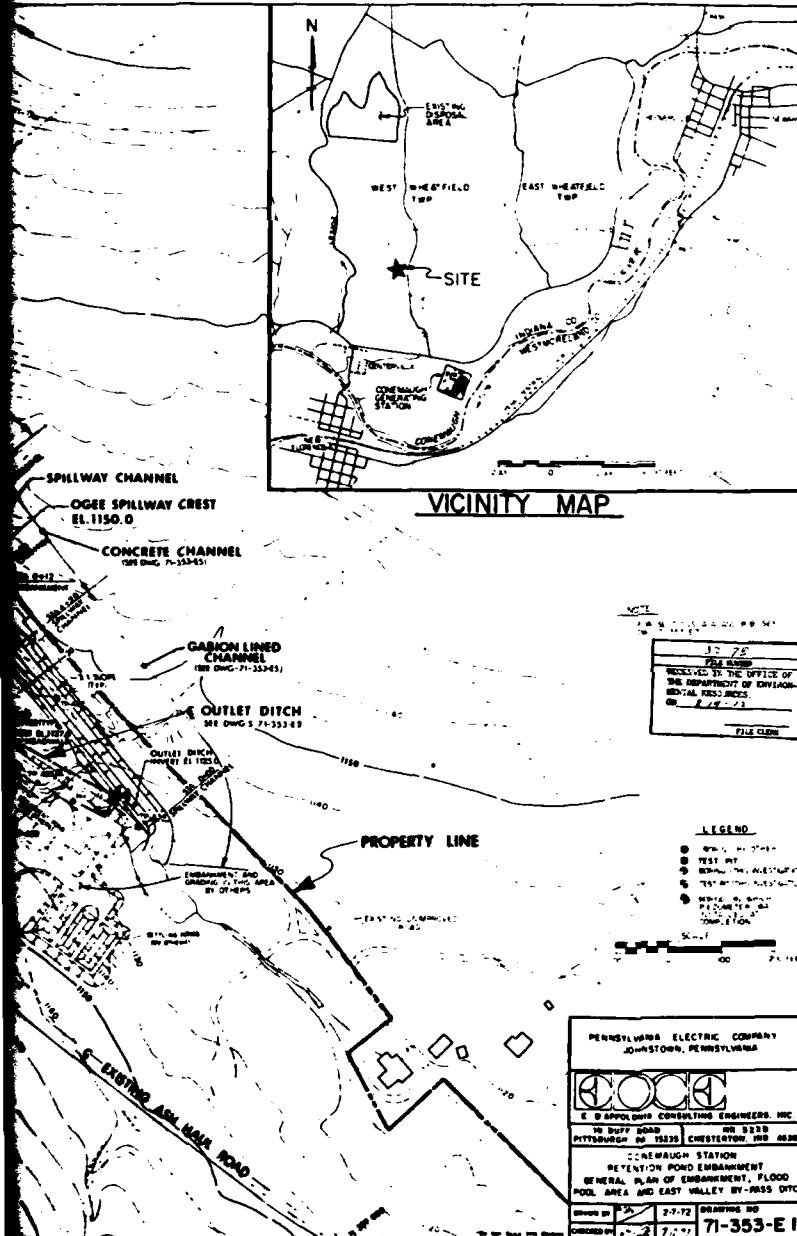
FIGURES

LIST OF FIGURES

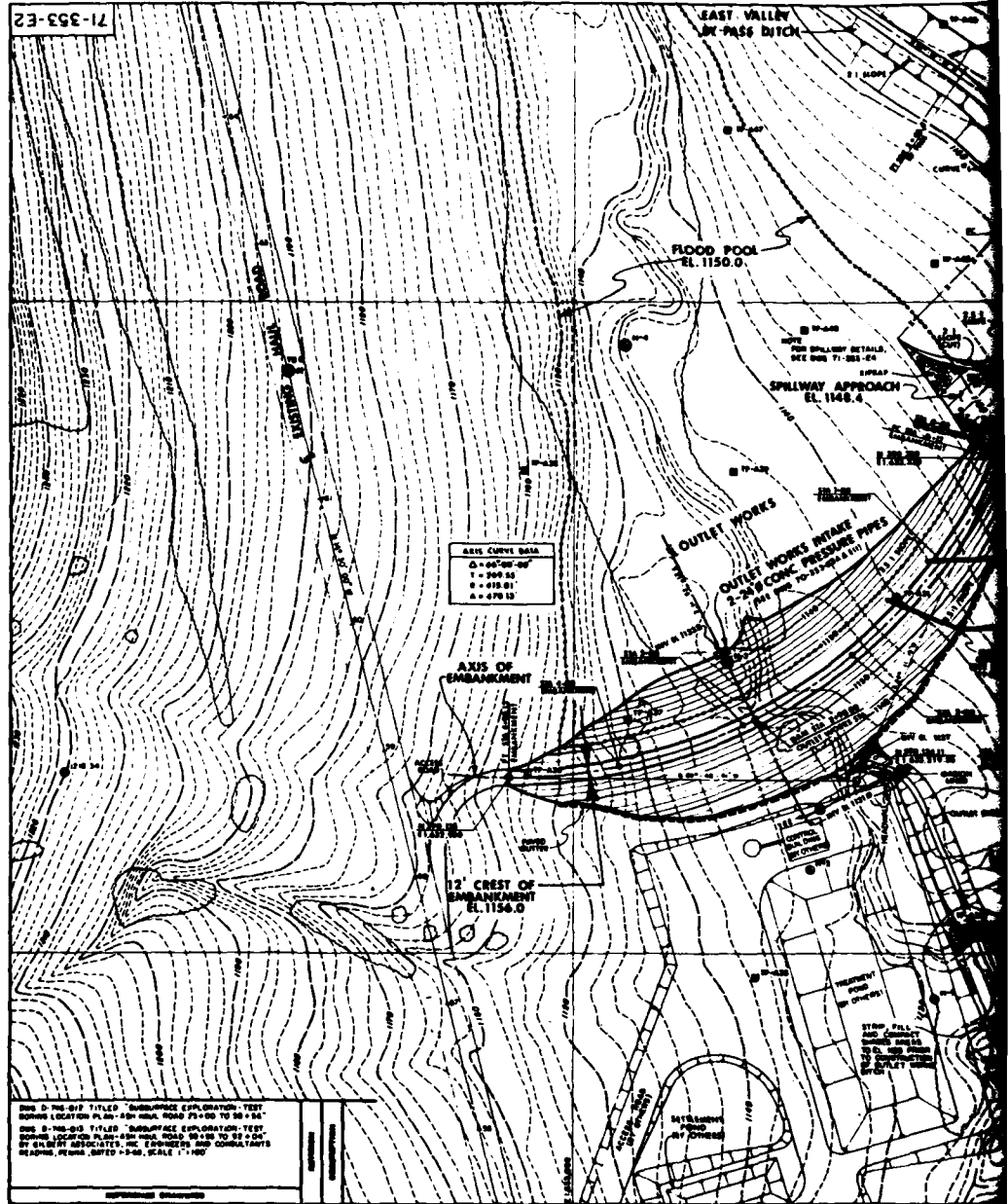
<u>Figure</u>	<u>Description/Title</u>
1	Regional Vicinity and Watershed Boundary Map
2	General Plan
3	Detailed Plan
4	Typical Sections
5	Plan and Section Through Outlet Works
6	Concrete Channel Details
7	Plan, Profile and Sections, Spillway Channel and Diversion Canal
8	Hydrology and Slope Stability
9	Subsurface Investigation Sections
10	Lab Data Sheet

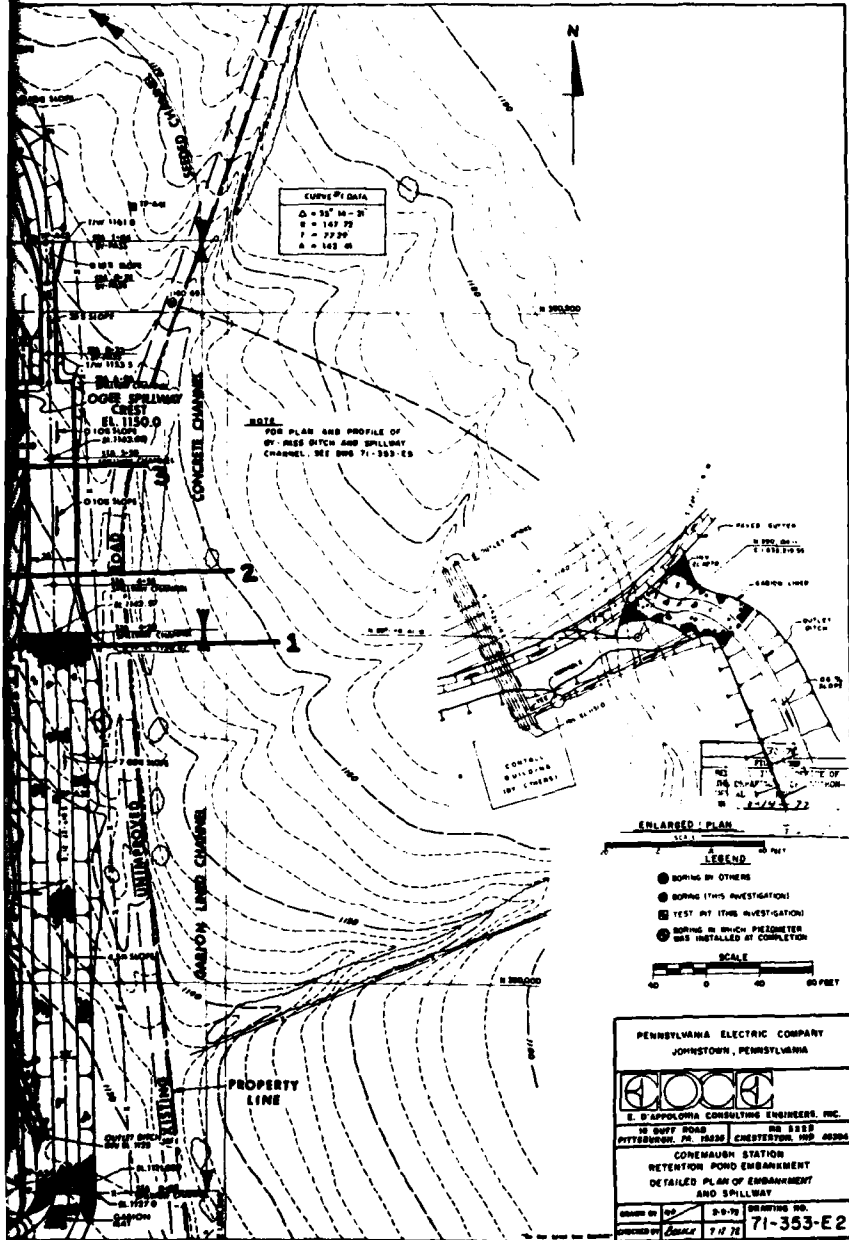


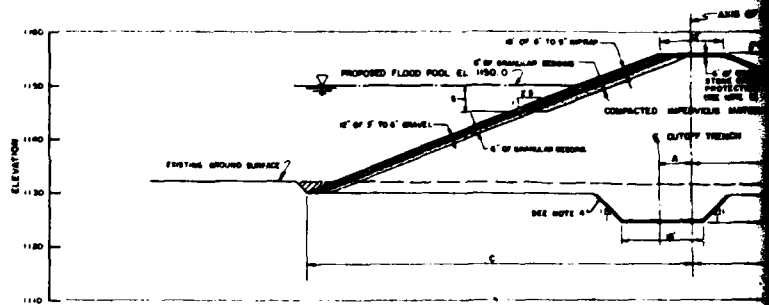




71-353-E2





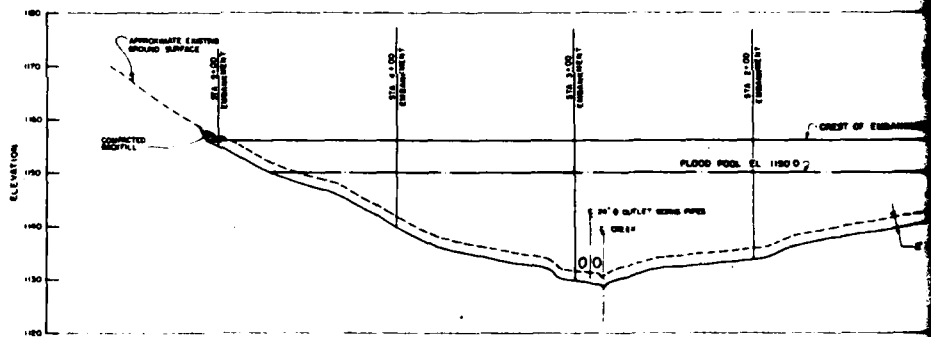


TYPICAL TRANSVERSE

SCALE: 1" = 10'

NOTES

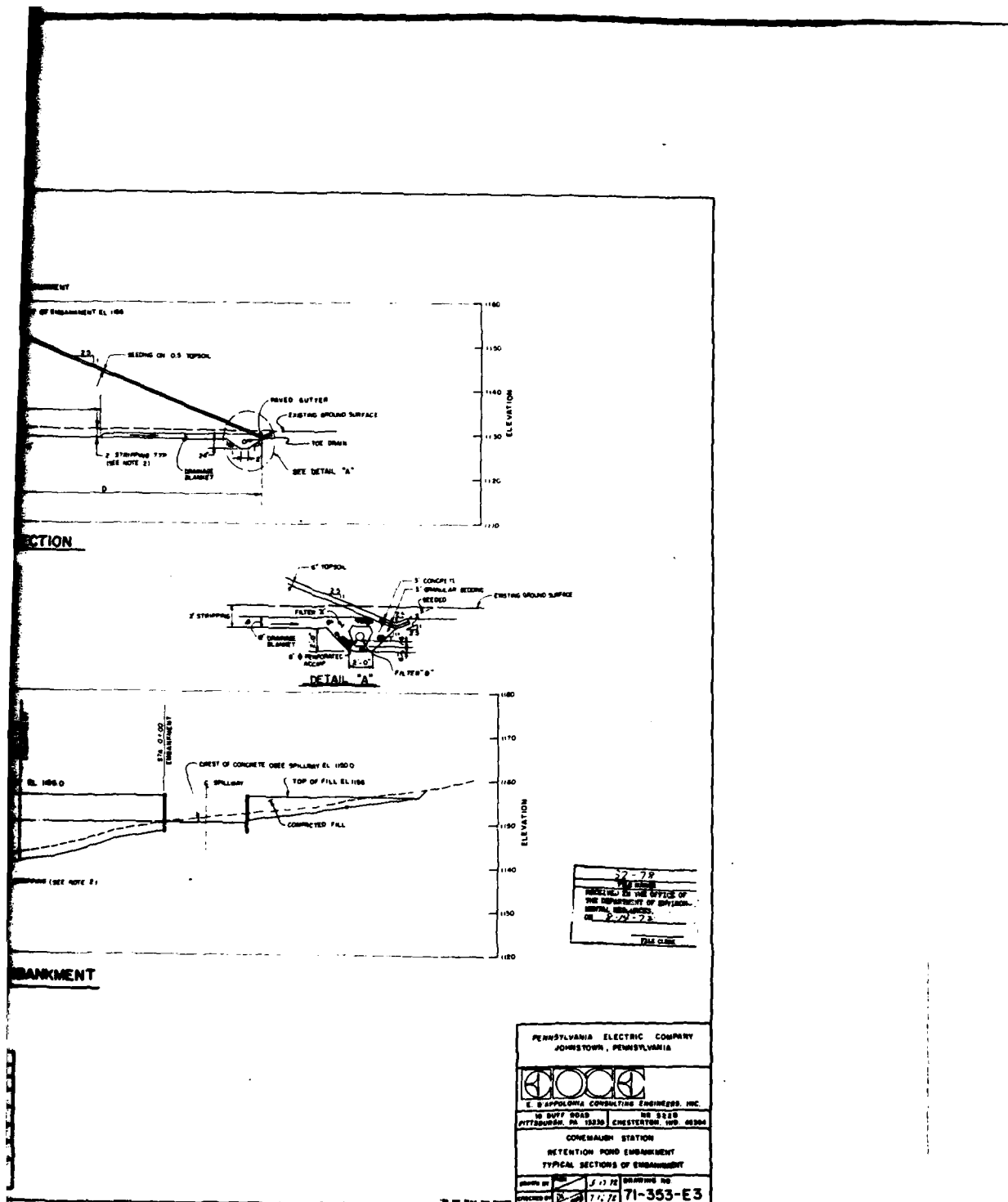
1. POP DIMENSIONS A, B, C AND D SEE TABLE 2
2. THE CEMENT STRUTTING SYSTEM UNDER THE EMBANKMENT IS 2 FEET. ADDITIONAL UNSATURATED MATERIAL WILL BE REMOVED AS DIRECTED BY THE FIELD ENGINEER
3. THE CRUST PROTECTION SHALL BE PLACED IN 6 INCHES. FURTHER SHALL BE 6 INCHES PLACED ON THE CRUST OF THE SAND. SECOND STAGE SHALL BE 6 PLACED ON THE ABOVE STAGE MATERIAL
4. CUTOFF TRENCH: EXCAVATED ROCK SURFACE TREATMENT AS DIRECTED BY FIELD ENGINEER TO BE A MINIMUM OF 3 FEET QUARTZ LAYER



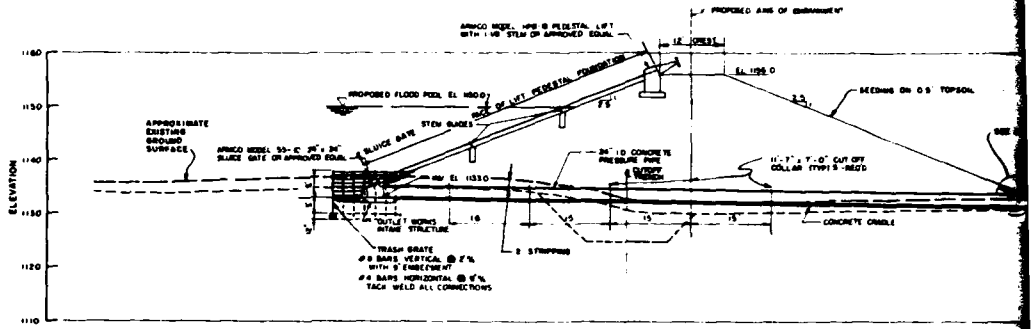
LONGITUDINAL SECTION AT 6 OF E

HORIZONTAL	SCALE	1" = 50'
VERTICAL	SCALE	1" = 10'

STATION	A	B	C	D
0 + 00	4	13	0	55
0 + 50	6	17	61	41
1 + 00	8	20	65	37
1 + 50	9	27	61	55
2 + 00	12	30	71	70
2 + 50	11	30	67	61
3 + 00	7	32	66	45
3 + 50	4	14	34	36
4 + 00	0			



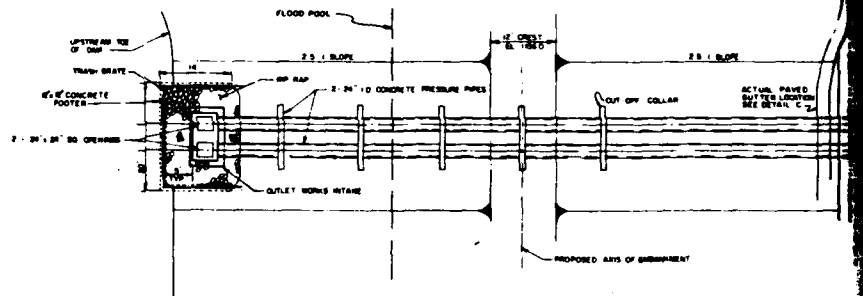
71-353-E3A



SECTION THROUGH OUTLET WORKS

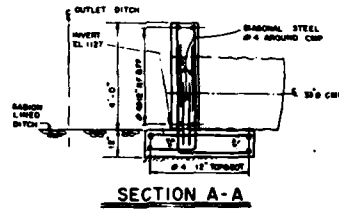
NOTE FOR ADDITIONAL DETAILS
SEE DWG. 71-353 E-11

SCALE 1" = 10'

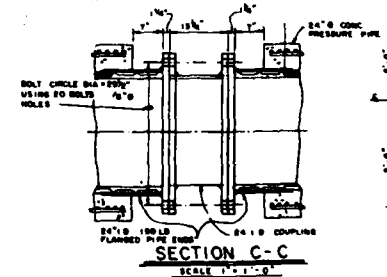


PLAN OF OUTLET WORKS

SCALE 1" = 10'



SECTION A-A

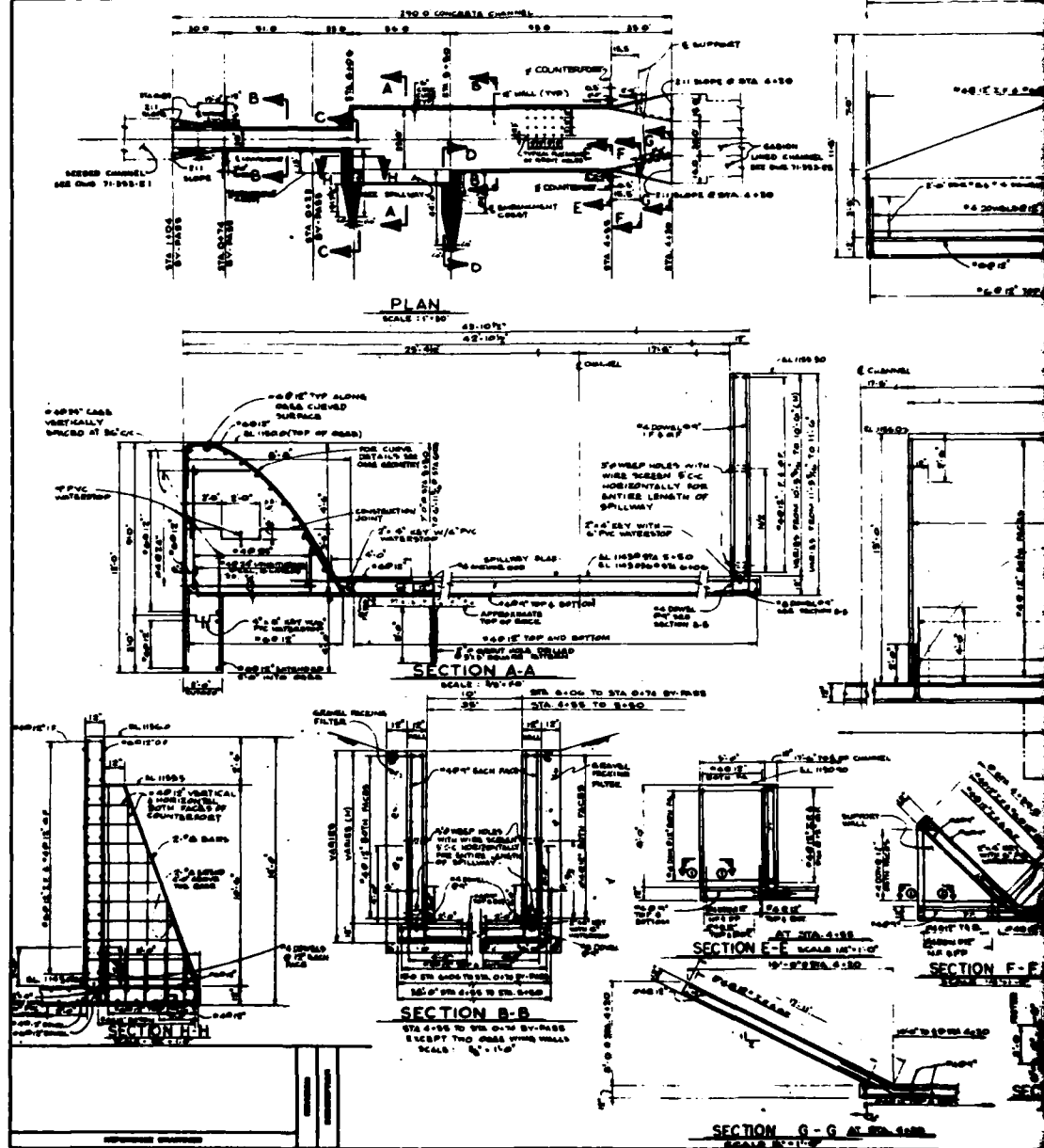


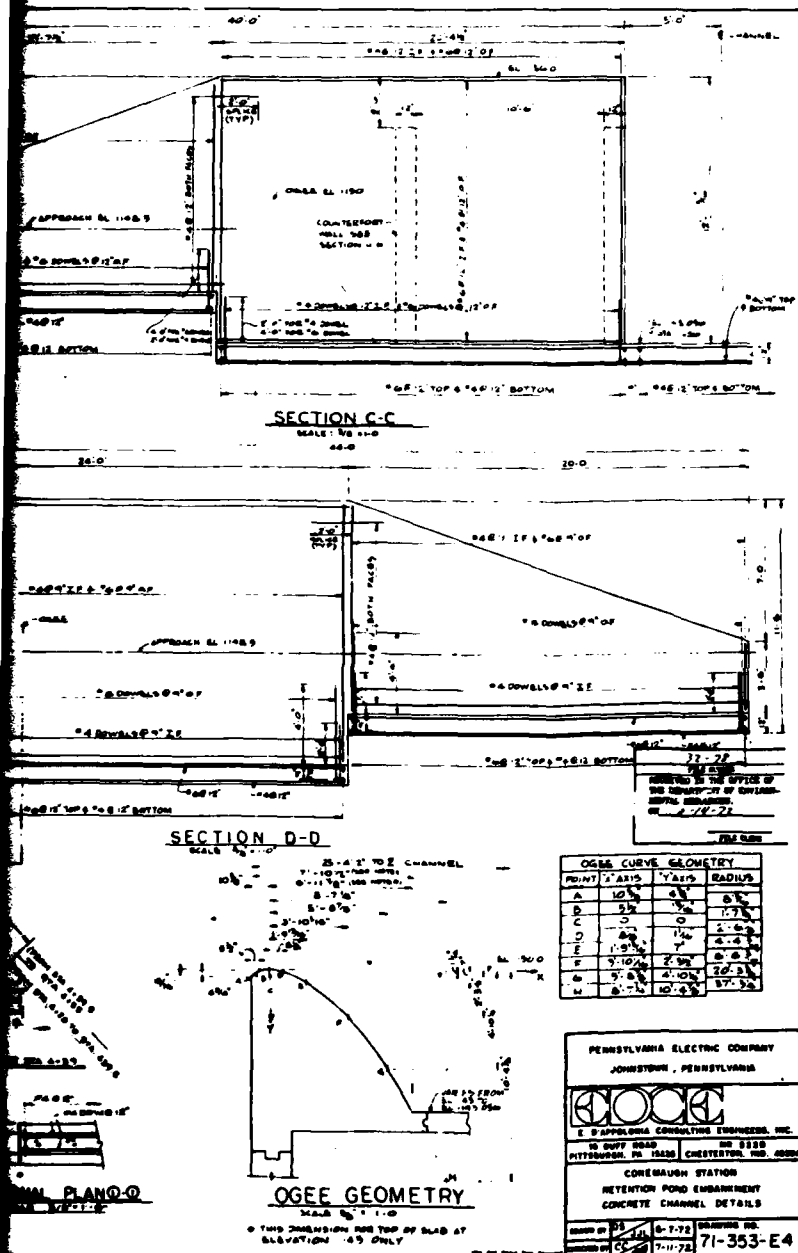
SECTION C-C

SCALE 1" = 1'-0"

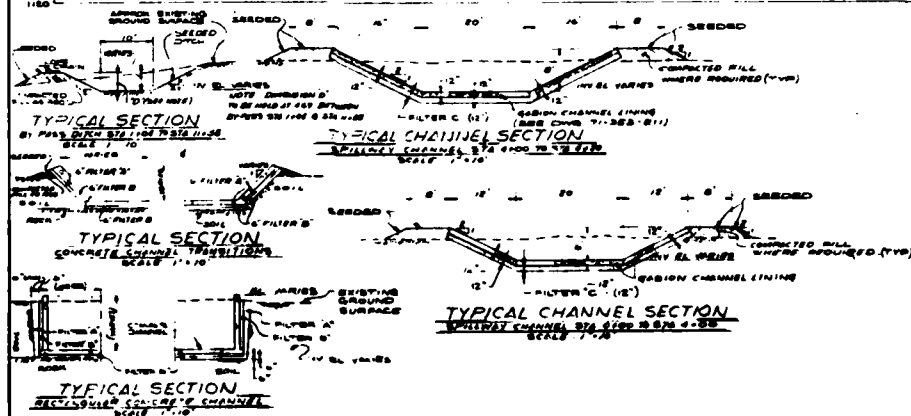
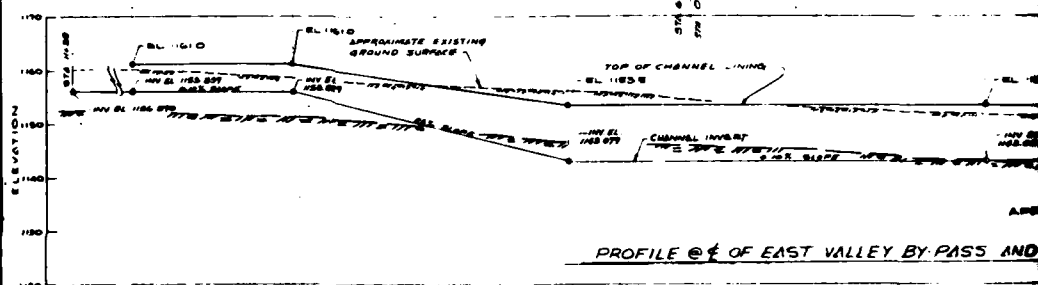
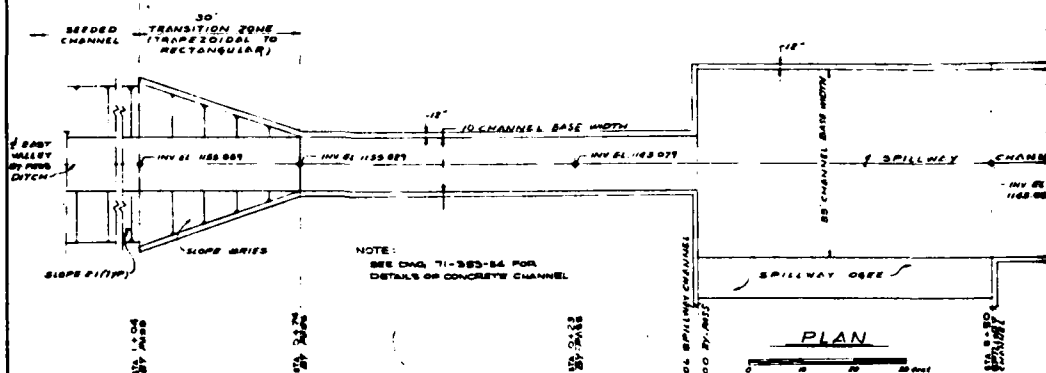


71-353-E4

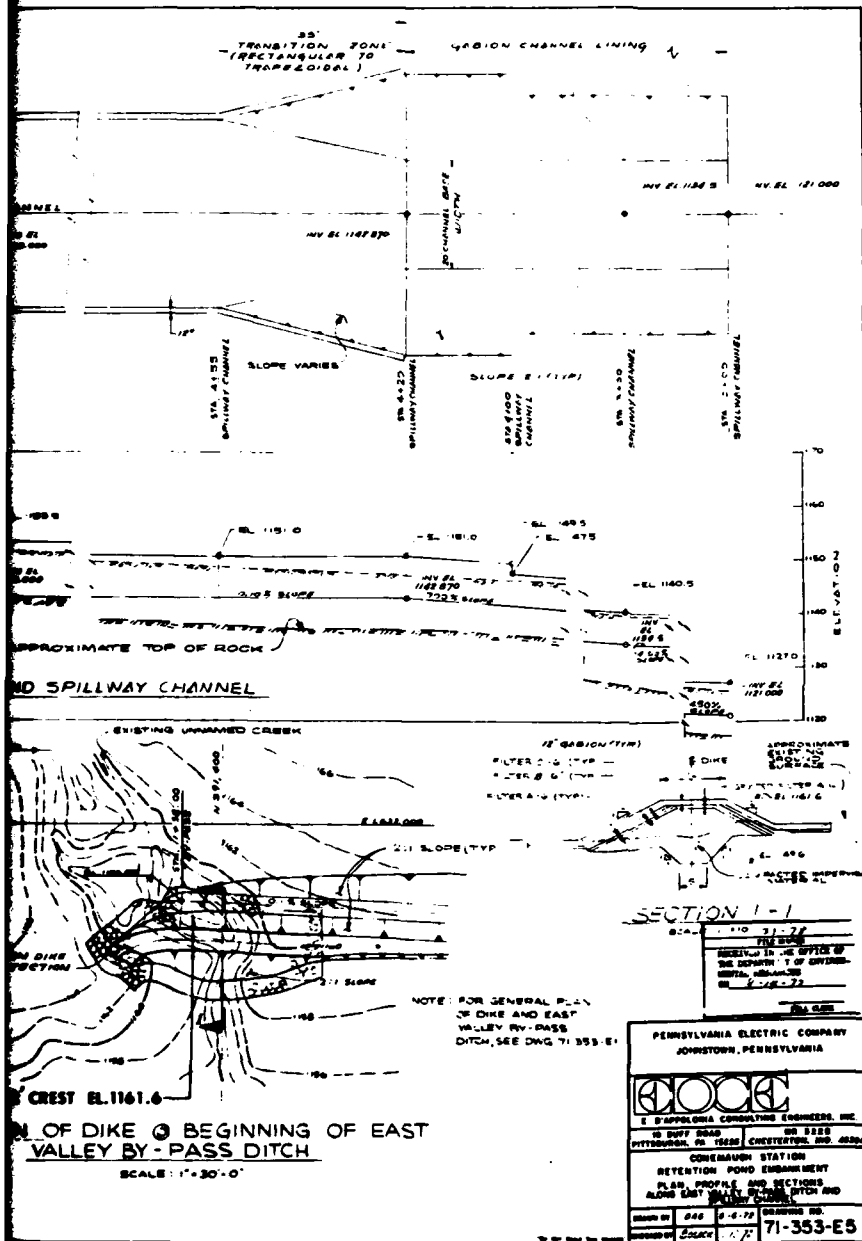




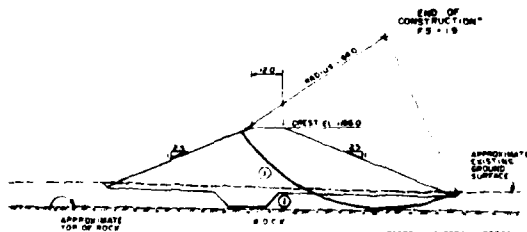
290 CONCRETE CHANNEL



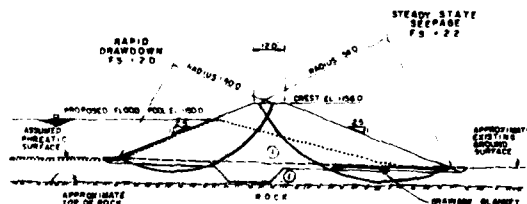
PLAN



71-353-E6



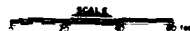
**SLOPE STABILITY ANALYSIS
END OF CONSTRUCTION**



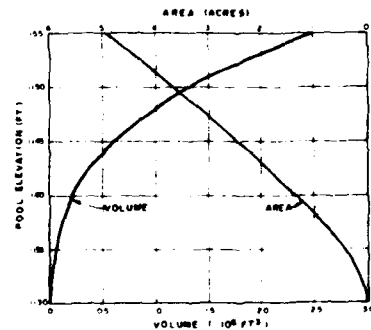
**SLOPE STABILITY ANALYSIS
RAPID DRAWDOWN & STEADY STATE SEEPAGE**

SOIL PROPERTIES

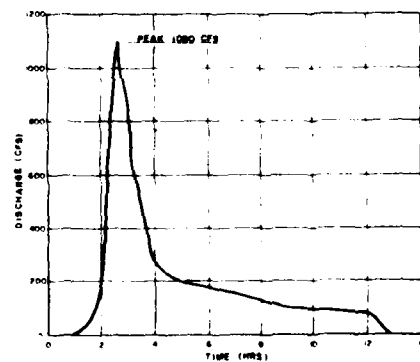
NO	DESCRIPTION	UNWEIGHTED AVERAGE	EFFECTIVE STRESS CORRELATION
1	CLAY SAND	52	100
			PPS



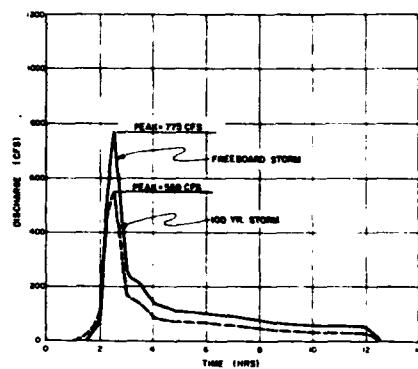
NOTE
STABILITY ANALYSES PERFORMED USING A COMPUTERIZED VERSION OF BISHOP'S METHOD OF SLICES



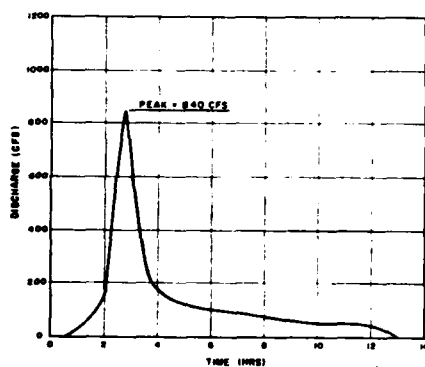
**POOL ELEVATION vs AREA & VOLUME
OF RETENTION POND**



**MAIN BASIN HYDROGRAPH
TYPICAL STORM**



EAST BASIN HYDROGRAPHS



**MAIN BASIN HYDROGRAPH
100 YR STORM**

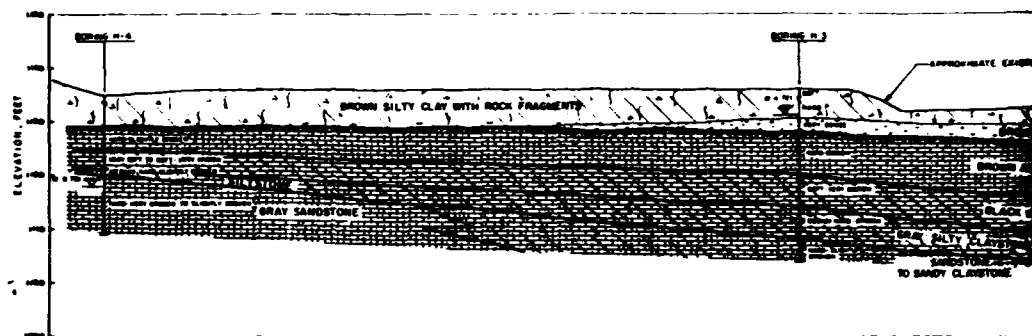
NOTE:

DESIGN PEAK OUTFLOWS FROM POND:
1149 CFS, 100 YR STORM,
1815 CFS, FREEBOARD STORM

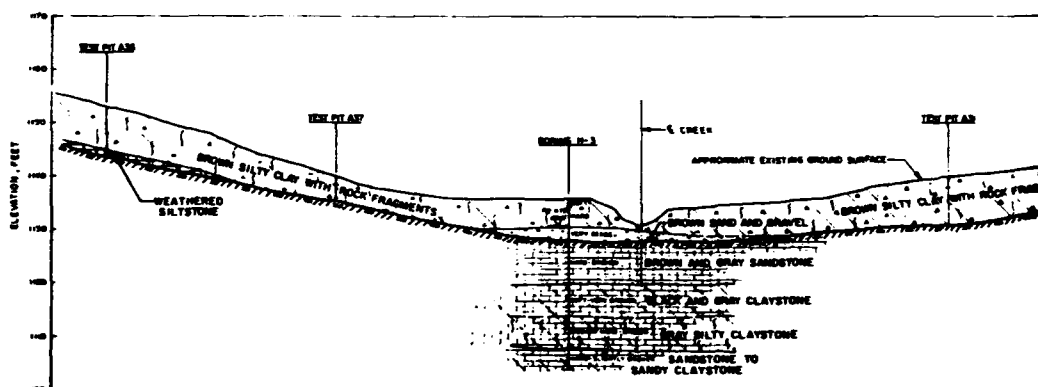
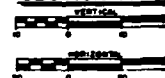
11-78
APPROVED TO THE M...
BY THE CHIEF OF DIV...
DATE 11-17-78
FILE 11-78

PENNSYLVANIA ELECTRIC COMPANY JOHNSTOWN, PENNSYLVANIA	
E. D'AMICO CONSULTING ENGINEERS, INC.	
15 SHUFF ROAD MYTHURTON, PA. 15854	DR. DEED CHESTERTON, MD. 20724
CONEMAUGH STATION RETENTION POND EMBANKMENT	
HYDROLOGY AND SLOPE STABILITY	
DESIGNED BY CHECKED BY DATE 7/17/78	DESIGNED NO. 71-353-E6

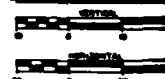
71-353-E7



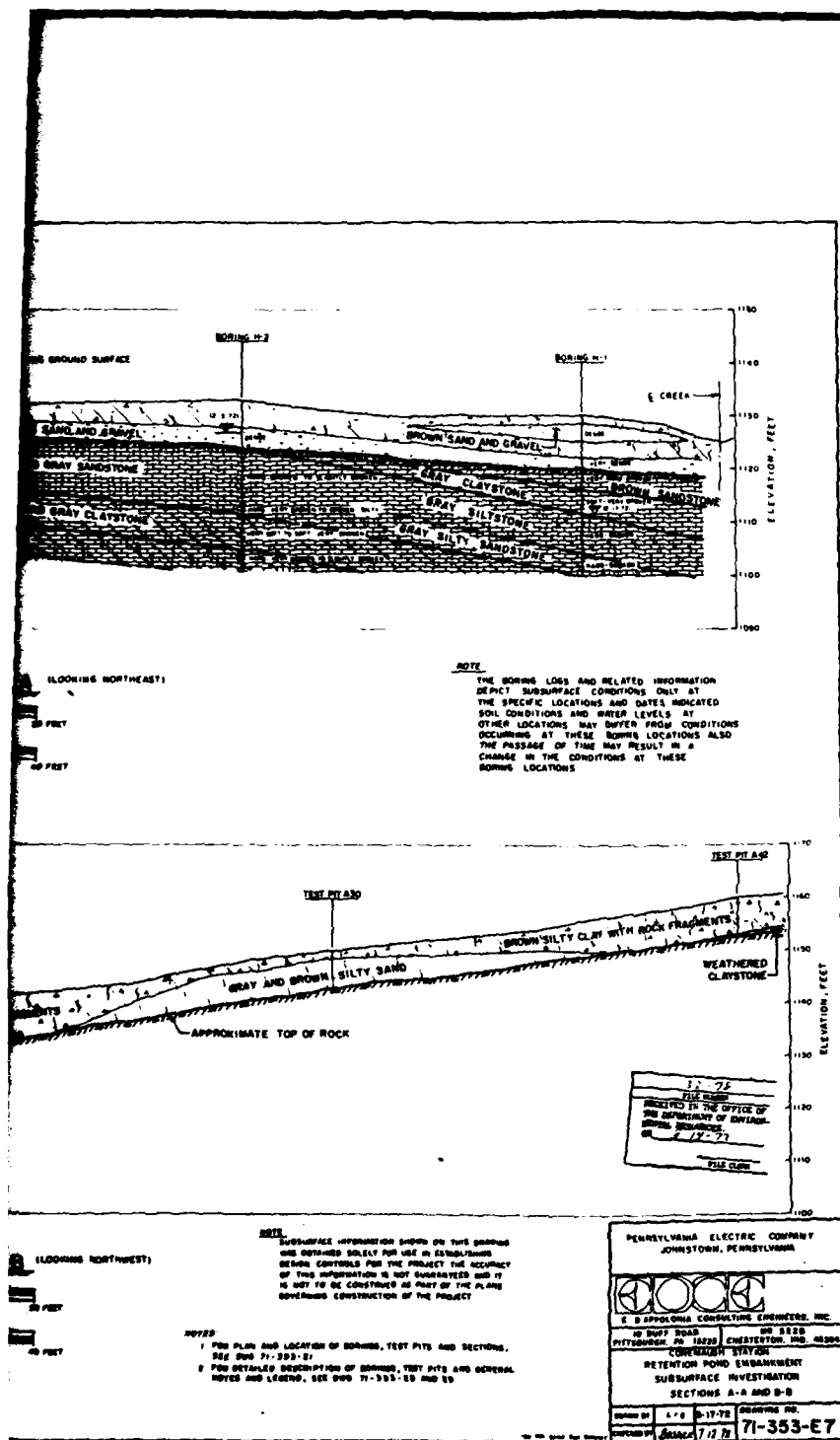
SECTION A-A



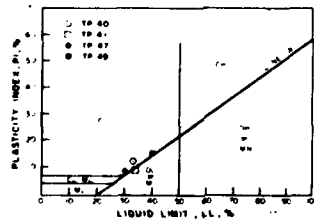
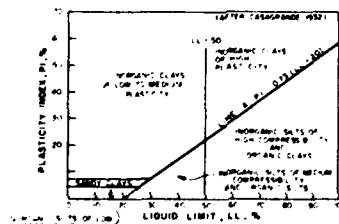
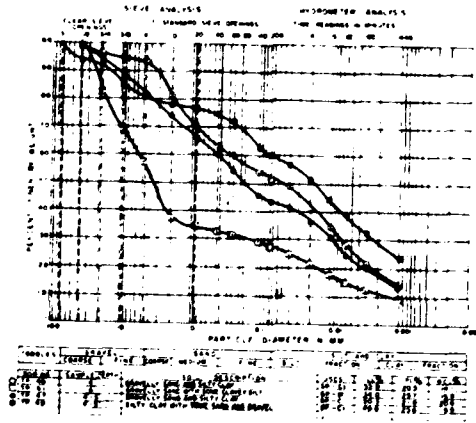
SECTION B-B



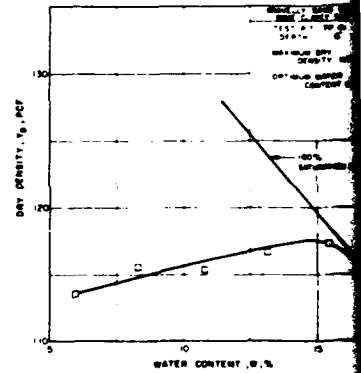
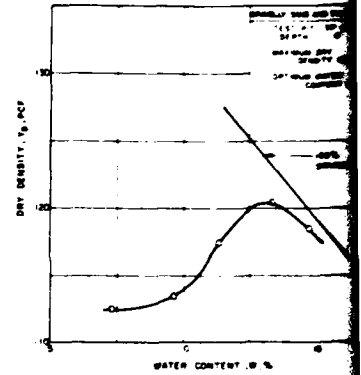
THE DEPTH AND THICKNESS OF THE SUBSURFACE STRATA INDICATED IN THE SECTIONS WERE DETERMINED FROM AND INTERPOLATED BETWEEN THE TEST BORINGS INFORMATION ON ACTUAL SUBSURFACE CONDITIONS EXIST ONLY AT THE LOCATION OF THE TEST BORINGS AND IT IS POSSIBLE THAT SUBSURFACE CONDITIONS BETWEEN THE TEST BORINGS MAY VARY FROM THOSE INDICATED



71-353-E10



PLASTICITY CHART

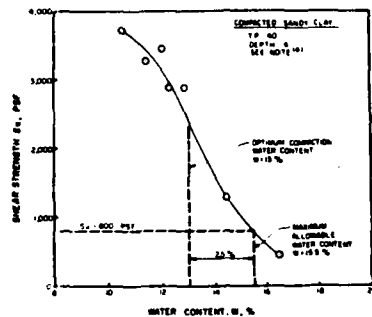


TEST NO.	DATE	LOCATION	DEPTH	TESTER	REMARKS
1	10/1/50	ROAD CUT	0-10	J. H. H.	CLAY
2	10/1/50	ROAD CUT	10-20	J. H. H.	CLAY
3	10/1/50	ROAD CUT	20-30	J. H. H.	CLAY
4	10/1/50	ROAD CUT	30-40	J. H. H.	CLAY
5	10/1/50	ROAD CUT	40-50	J. H. H.	CLAY

MOISTURE-DENSITY RELATIONS FROM STANDARD COMPACTION TEST

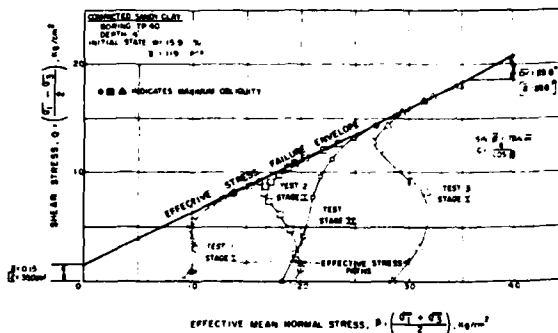
- W = water content
- ρ_d = dry density
- ρ_w = water density
- ρ_s = solids density
- ρ_{max} = maximum dry density
- w_p = plasticity index
- w_L = liquid limit
- w_U = upper liquid limit
- w_N = natural water content
- w_{opt} = optimum water content
- w_{max} = maximum water content
- w_{min} = minimum water content
- w_{avg} = average water content
- w_{std} = standard water content
- w_{var} = variable water content
- w_{tot} = total water content
- w_{rel} = relative water content
- w_{abs} = absolute water content
- w_{vol} = volumetric water content
- w_{mass} = mass water content
- w_{dry} = dry water content
- w_{wet} = wet water content
- w_{sat} = saturation water content
- w_{air} = air water content
- w_{vac} = vacuum water content
- w_{atm} = atmospheric water content
- w_{baro} = barometric water content
- w_{hyd} = hydrostatic water content
- w_{ther} = thermodynamic water content
- w_{chem} = chemical water content
- w_{bio} = biological water content
- w_{geo} = geologic water content
- w_{cos} = cosmic water content
- w_{solar} = solar water content
- w_{lunar} = lunar water content
- $w_{stellar}$ = stellar water content
- $w_{galactic}$ = galactic water content
- $w_{universal}$ = universal water content

- W = water content
- ρ_d = dry density
- ρ_w = water density
- ρ_s = solids density
- ρ_{max} = maximum dry density
- w_p = plasticity index
- w_L = liquid limit
- w_U = upper liquid limit
- w_N = natural water content
- w_{opt} = optimum water content
- w_{max} = maximum water content
- w_{min} = minimum water content
- w_{avg} = average water content
- w_{std} = standard water content
- w_{var} = variable water content
- w_{tot} = total water content
- w_{rel} = relative water content
- w_{abs} = absolute water content
- w_{vol} = volumetric water content
- w_{mass} = mass water content
- w_{dry} = dry water content
- w_{wet} = wet water content
- w_{sat} = saturation water content
- w_{air} = air water content
- w_{vac} = vacuum water content
- w_{atm} = atmospheric water content
- w_{baro} = barometric water content
- w_{hyd} = hydrostatic water content
- w_{ther} = thermodynamic water content
- w_{chem} = chemical water content
- w_{bio} = biological water content
- w_{geo} = geologic water content
- w_{cos} = cosmic water content
- w_{solar} = solar water content
- w_{lunar} = lunar water content
- $w_{stellar}$ = stellar water content
- $w_{galactic}$ = galactic water content
- $w_{universal}$ = universal water content



NOTE: TOTAL STRESS SHEAR STRENGTH AS A FUNCTION OF WATER CONTENT OBTAINED FROM UNCOMPACTED COMPACTION TESTS ON HOMOGENEOUS SAMPLES

MOISTURE - SHEAR STRENGTH RELATION OF COMPACTED SANDY CLAY



STRAIN RATE - 0.005 mm/min
 BACK PRESSURE - 7.5 kN/m²
 CONSOLIDATION TIME - 1 DAY

SAMPLE DIMENSIONS
 DIAMETER - 38 mm
 LENGTH - 200 mm

NOTE: TESTS WERE CONDUCTED ON MATERIAL PASSING NO. 40 SIEVE

CONSOLIDATED UNDRAINED TRIAXIAL TEST

7-1-76
TEST NO.
RECEIVED IN THE OFFICE OF THE DEPARTMENT OF TRANSPORTATION
DATE 1-17-77
FILE NO.

PENNSYLVANIA ELECTRIC COMPANY JOHNSTOWN, PENNSYLVANIA	
E. B. APPELON CONSULTING ENGINEERS, INC.	
1000 N. 10TH ST. JOHNSTOWN, PA. 15136	1000 N. 10TH ST. JOHNSTOWN, PA. 15136
CONSTRUCTION STATION RETENTION POND EMBANKMENT LAB DATA SHEET	
DESIGNED BY: PJP	DRAWING NO.: 71-353-E10
CHECKED BY: JJP	

APPENDIX F

GEOLOGY

Geology.

Penelec Retention Dam is located in the Allegheny Mountain section of the Appalachian Plateau province of west central Pennsylvania. In this area, the Allegheny Mountain section is characterized by gently folded sedimentary rock strata of Middle Pennsylvanian age. Major structural axes strike from southwest to northeast with flanking strata dipping northwest and southeast.

Structurally, the dam and reservoir lie about 1-mile northwest of the Ligonier syncline and about 5 miles northwest of the Laurel Hill anticline, both of which strike in the regional southwest to northeast trend.

The sedimentary rock sequence contained in the abutments and immediately underlying the embankment are members of the Conemaugh Group of Pennsylvanian age. The rocks of this group typically exhibit the rapid vertical and lateral lithologic changes characteristic of cyclic sedimentation. In this area, the Conemaugh Formation consists of a variable sequence of sandstone, shale, clay, thin coals, and thin beds of limestone.

A subsurface investigation of the site was conducted in 1972 with the results presented in the "Engineer's Report". The soil and rock conditions underlying the proposed embankment were explored with 23 test pits and borings. The Engineer's Report disclosed the following subsurface conditions:

"8-11 feet of hard, broken brown and gray sandstone; overlying 5-6 feet of soft, very broken black and gray claystone; overlying greater than 5 feet of hard slightly broken sandstone to sandy claystone."

Soils were described as:

"residual, derived from siltstone, claystone, sandstone, and shale lithologic units. The soils vary in depth from thin veneers to deeply weathered zones, and their permeable nature ranges from poorly drained to well drained."

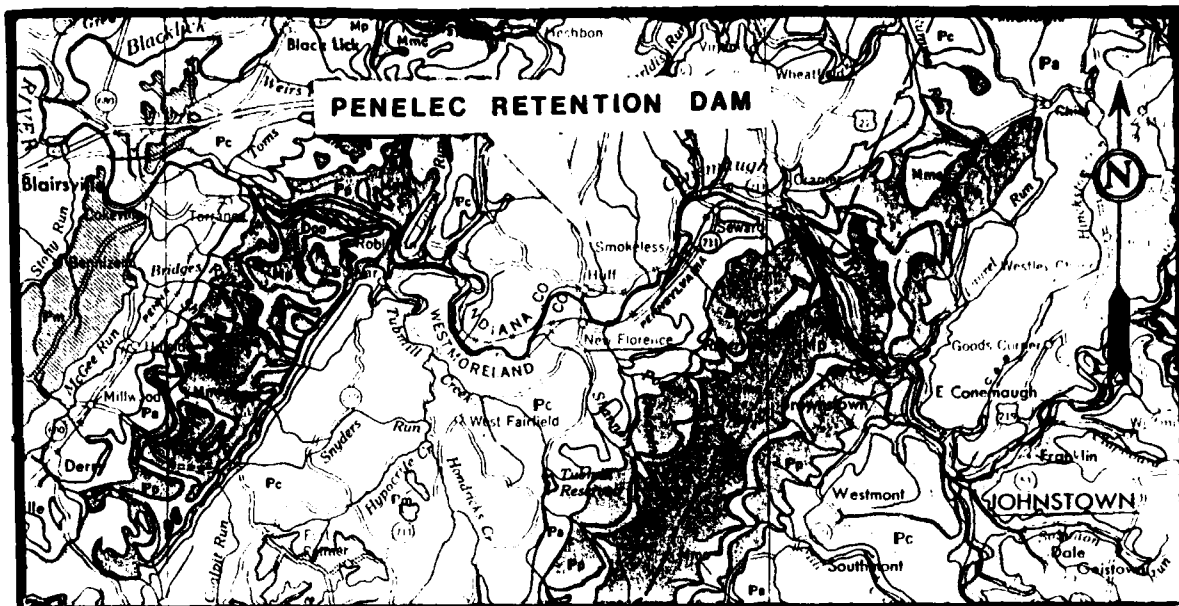
Mining conditions were described as:

"Mining of one coal seam (known locally as the "B" seam) by the North American Coal Company has extended to just within the vicinity of the proposed embankment."

The coal was mined in the period 1953 to 1954, initially by the room and pillar method, and subsequently by retreat mining. The mine was nominally 300 feet below the surface in the vicinity of the proposed embankment. Discussions with cognizant mining personnel indicate that controlled subsidence has occurred within the vicinity of the retention pond embankment. A detailed surficial study of this area showed no evidence of subsidence at the surface."

References

- ¹Lohman, Stanley W., "Groundwater in South-Central Pennsylvania," Water Resource Report No. 5, Pennsylvania Geological Survey, Fourth Series, Harrisburg, 1938.
- ²Shaffner, M. N., "Preliminary Map of Geologic Structure on Base of Lower Kittanning Coal in New Florence Quadrangle, Pennsylvania," Pennsylvania Geological Survey, Fourth Series, Progress Report No. 137, 1951.
- ³Engineer's Report, Retention Pond Embankment, Conemaugh Station Ash and Mine Refuse Disposal Area, Pennsylvania Electric Company, Johnstown, Pennsylvania, E. D'Appolonia Consulting Engineers, Inc., 1972.



LEGEND

PENNSYLVANIAN

APPALACHIAN PLATEAU



Monongahela Formation

Cyclic sequences of sandstone, shale, limestone and coal; limestone prominent in northern outcrop areas; shale and sandstone increase southward; commercial coals present; base at the bottom of the Pittsburgh Coal.



Conemaugh Formation

Cyclic sequences of red and gray shales and siltstones with thin limestones and coals; massive Mahoning Sandstone commonly present at base; Ames Limestone present in middle of section; Brush Creek Limestone in lower part of section.



Allegheny Group

Cyclic sequences of sandstone, shale, limestone and coal; numerous commercial coals; limestones thicken westward; Vanport Limestone in lower part of section; includes Freeport, Kittanning, and Clarion Formations.



Pottsville Group

Predominantly sandstones and conglomerates with thin shales and coals; some coals mineable locally.

MISSISSIPPIAN



Mauch Chunk Formation

Red shales with brown to greenish gray flaggy sandstones; includes Greenbrier Limestone in Fayette, Westmoreland, and Somerset counties; Loyahanna Limestone at the base in southwestern Pennsylvania.



Pocono Group

Predominantly gray, hard, massive, cross-bedded sandstones and shales with some shale; includes in the Appalachian Plateau: Rurgoon, Shenango, Cuyahoga, Cussewago, Curry, and Knapp Formations; includes part of "Onaway" of M. L. Fuller in Potter and Tioga counties.

DEVONIAN



Onaway Formation

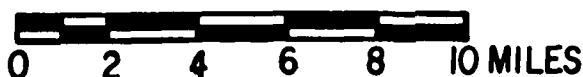
Brownish and greenish gray, fine and medium grained sandstones with some shales and scattered calcareous lenses; includes red shales which become more numerous eastward. Relation to type Onaway not proved.



Catskill Formation

Chiefly red to brownish shales and sandstones; includes gray and greenish sandstone lenses named Elk Mountain, Honestale, Shohola, and Delaware River in the east.

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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