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SUSQUEHANNA RIVER BASIN
MIDDLE BRANCH OF CHILLISQUAQUE CREEK, MONTOUR COUNTY

PENNSYLVANIA

LEVEL II

LAKE CHILLISQUAQUE

NDS ID NO. PA-815

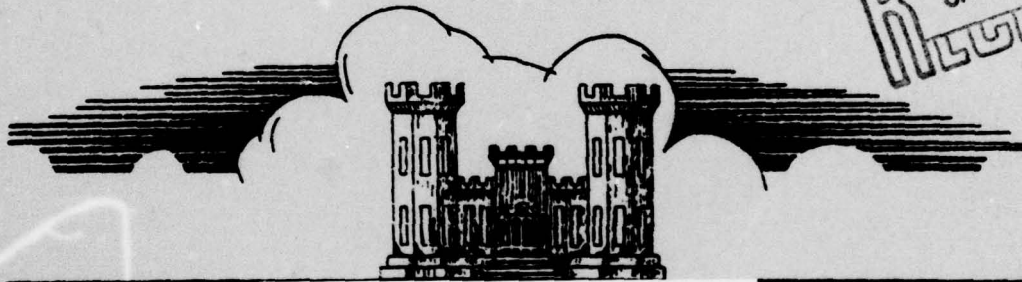
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PENNSYLVANIA POWER & LIGHT COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

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Prepared By

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG, PENNSYLVANIA
15931

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BALTIMORE DISTRICT CORPS OF ENGINEERS
BALTIMORE, MARYLAND

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SUSQUEHANNA RIVER BASIN
MIDDLE BRANCH OF CHILLISQUAQUE CREEK, MONTOUR COUNTY

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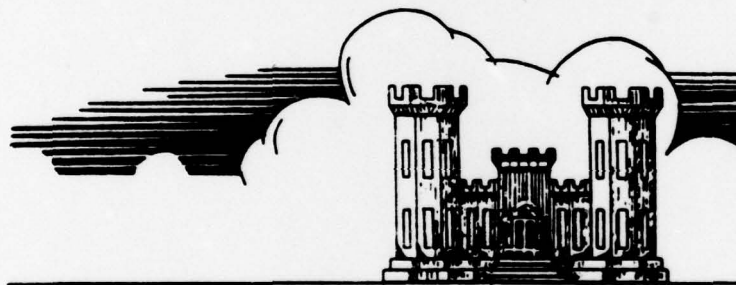
PENNSYLVANIA

6 National Dam Inspection Program.
LAKE CHILLISQUAQUE

(NDS ID NO. PA-815 Number)
(Number DER ID NO. 47-8), Susquehanna River Basin,
Middle Branch of Chillisquaque Creek, Montour County,
PENNSYLVANIA POWER & LIGHT COMPANY

PHASE I INSPECTION REPORT,
NATIONAL DAM INSPECTION PROGRAM

Pennsylvania



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10 R. Jeffrey / Kimball
Kuang Hwei / Chuang

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FOR
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BALTIMORE, MARYLAND
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AUGUST, 1979

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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. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

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

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PHASE I REPORT
NATIONAL DAM INSPECTION REPORT

NAME OF DAM: Lake Chillisquaque Dam
STATE LOCATED: Pennsylvania
COUNTY LOCATED: Montour
STREAM: Middle Branch of Chillisquaque Creek
DATE OF INSPECTION: May 23, 1979

ASSESSMENT

The assessment of Lake Chillisquaque Dam is based upon visual observations made at the time of inspection, review of available records and data, hydrology and hydraulic computations, and past operational performance.

The inspection and review of data of Lake Chillisquaque Dam did not reveal any problems which require emergency action. The dam appears to be stable, well maintained, safely operated and in good condition.

Lake Chillisquaque is a high hazard-intermediate size dam. The spillway design flood is the PMF (Probable Maximum Flood). The spillway and reservoir are capable of controlling the PMF. Based on criteria established by the Corps of Engineers, the spillway is termed adequate.

The following recommendations and remedial measures should be instituted immediately.

1. Continue to remove all trees from the embankment.
2. The wet areas at the toe of the embankment should be examined during the routine inspections. Drainage from these areas should be provided and flow monitored when it exists.
3. A formal inspection program should be instituted.
4. A warning system should be instituted to warn downstream residents of large spillway discharges or failure of the dam.
5. Valves should be operated and lubricated on a regularly scheduled basis.



SUBMITTED BY: L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS AND ARCHITECTS

R. Jeffrey Kimball
R. Jeffrey Kimball, P.E.

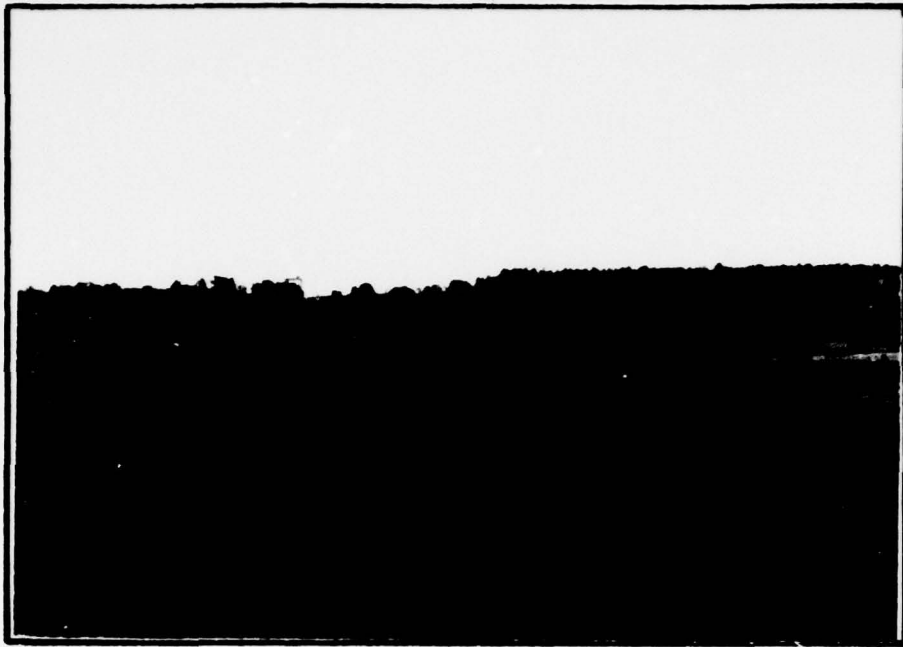
Date

K. Chuang
Kuang Hwei Chuang, P.E.

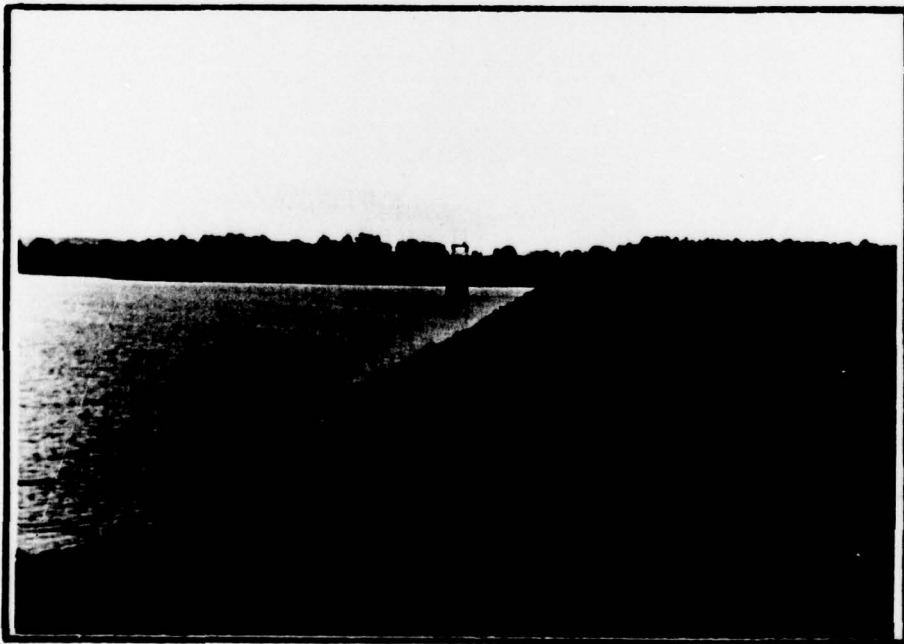
APPROVED BY:

16 August 1979
Date

James W. Peck
JAMES W. PECK
Colonel, Corps of Engineers
District Engineer



Overview of downstream slope from right abutment.



Overview of upstream slope and crest from right abutment.

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PHASE I
NATIONAL DAM INSPECTION PROGRAM
LAKE CHILLISQUAQUE
NDI I.D. NO. PA 815
DER I.D. NO. 47-8

SECTION 1
PROJECT INFORMATION

1.1 General.

a. Authority. The National 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.

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

1.2 Description of Project.

a. Dam and Appurtenances. Lake Chillisquaque is an earth-fill dam 2000 feet long and 54 feet high. The dam is a zoned earth embankment with a center core consisting of silty clay material and the upstream and downstream portions consisting of weathered shale. The upstream and downstream slopes were constructed at 2.5H:1V with berms at elevation 582.0. The crest of the dam is 12 feet wide and forms an access road at elevation 605.5. The outlet works consist of a concrete control tower connected to two 36" steel pipes encased in concrete. The outlet works has a positive upstream shut off in the form of a bulkhead. The flow through these pipes is regulated by a 36" sluice gate, an 18" cone valve or an 8" by pass valve. At the toe of the dam is a valve house to control flow through these pipes. The earthen emergency spillway is located on the left abutment and contains a concrete sill 750 feet long. The spillway discharge channel is 1300 feet long and discharges to a natural stream.

b. Location. The dam is located on Middle Branch of Chillisquaque Creek, approximately 1.7 miles north of Strawberry Ridge, Montour County Pennsylvania. Lake Chillisquaque can be located on the Washingtonville U.S.G.S. 7.5 minute quadrangle.

c. Size Classification. Lake Chillisquaque Dam is an intermediate size structure (54 feet high, 4400 acre-feet).

d. Hazard Classification. Lake Chillisquaque is a high hazard dam. Downstream conditions indicate that loss of more than a few lives is probable should the structure fail. (See section 3.1e).

e. Ownership. Lake Chillisquaque is owned by the Pennsylvania Power and Light Company. Correspondence should be addressed to:

Pennsylvania Power and Light Company
901 Hamilton Street
Allentown, PA 18101
215-821-5151

f. Purpose of Dam. Lake Chillisquaque is used for water supply for the Montour Power Plant, recreation and flood control.

g. Design and Construction History. The dam was designed by Ebasco Services Inc. The dam was constructed by Vipond and Vipond with Ebasco performing the construction inspection. The dam was completed in 1971.

h. Normal Operating Procedures. The reservoir is used for storage of emergency cooling water for the Montour Power Plant. In addition to normal inflow, the reservoir has a 48" supply line from the Susquehanna River to add water to the reservoir. Normal operation of the reservoir requires that the 8" bypass line be open to pass the minimum flow to the stream. All valves are operated automatically from the power plant. In addition, the valves can be operated manually from the dam. Normal water level is at elevation 594.0. During flooding periods the following procedures are utilized:

1. At elevation 596 the pumps from the Susquehanna River are stopped.
2. At elevation 597 the 8" by pass line is opened full.
3. At elevation 598 the 18" valve is opened. The amount of opening of the 18" valve may be limited by plant makeup water and critical cooling water requirements.
4. At elevation 598.5 the curator of the Montour Preserve inspects the emergency overflow to assure that it is clear of debris.

1.3 Pertinent Data.

a. <u>Drainage Area.</u>	5.6 square miles
b. <u>Discharge at Dam Site (cfs).</u>	
Maximum known flood at dam site	Approximately 4500 cfs September, 1975, elev. 601.6
36" drain line at normal pool elevation	Unknown
Emergency spillway capacity at top of dam	29022

c. Elevation (U.S.G.S Datum) (feet). - Elevations worked from spillway crest elevation 600 obtained from construction drawings.

Top of dam - low point	605.5
Top of dam - design height	605.0
Maximum pool - design surcharge	604.5
Full flood control pool	600.0
Normal pool	594.0
Emergency spillway crest	600.0
Upstream portal - 36" drain line	552.5
Downstream portal - 36" drain line	551.4
Streambed at centerline of dam	551.4
Maximum tailwater	None
Toe of dam	551.4

d. Reservoir (feet).

Length of maximum pool	6000
Length of normal pool	5000
Length of flood control pool	5500

e. Storage (acre-feet).

Normal pool	2200
Flood control pool	3300
Top of dam	4400

f. Reservoir Surface (acres).

Top of dam	220
Maximum pool	220
Flood control pool	167
Normal pool	113
Spillway crest	167

g. Dam.

Type	Earthfill
Length	2000 feet
Height	54 feet
Top width	12 feet
Side slopes	Both 2.5H:1V with berms
Zoning	Yes
Impervious core	Yes
Cutoff	Yes
Grout curtain	Yes

h. Reservoir Drain.

Type	36" steel pipe
Length	220 feet
Closure	Sluice gate in control tower
Access	From control tower
Regulating facilities	Sluice gate in control tower

i. Spillway.

Type	Uncontrolled concrete sill
Length	750 feet
Crest elevation	600.0
Gates	None
Upstream channel	Lake
Downstream channel	1300 foot long cut in natural ground

SECTION 2
ENGINEERING DATA

2.1 Design. Review of information in the files of the Commonwealth of Pennsylvania, Department of Environmental Resources and the Pennsylvania Power & Light Company revealed that construction drawings, design reports, permits and photographs were available for review. All this data was reviewed for this study.

2.2 Construction. Construction reports are available at the Pennsylvania Power & Light Company's office.

2.3 Operation. Operating records are maintained at the Montour Power Station. Continuous readings are recorded on reservoir level and discharges to the stream.

2.4 Evaluation.

a. Availability. Engineering data were provided by PennDER Bureau of Dam Safety, Obstructions and Storm Water Management and the Pennsylvania Power & Light Company. Members of the Pennsylvania Power & Light Company accompanied the inspection team to answer questions on construction, design and operation of the dam.

b. Adequacy. The type and amount of design data and other engineering information is substantial. The information is sufficient to complete a Phase I Report.

SECTION 3
VISUAL INSPECTION

3.1 Findings.

a. General. The onsite inspection of Lake Chillisquaque was conducted by personnel of L. Robert Kimball and Associates accompanied by members of the engineering staff of Pennsylvania Power and Light Company on May 23, 1979. The inspection consisted of :

1. Visual inspection of the retaining structure, abutments and toe.
2. Examination of the spillway facilities, exposed portions of any outlet works and other appurtenant works.
3. Observations affecting the runoff potential of the drainage basin.
4. Evaluation of the downstream area hazard potential.

b. Dam. The dam appears to be in good condition. The dam appears to conform closely to the construction drawings. From a brief survey conducted during the inspection, it was noted that the crest of the dam is higher than the design height. It appears that additional material was placed to form an access road over the top of dam. The upstream and downstream slopes were measured at 2.5H:1V and were covered with weathered shale. No vegetation is growing on these slopes with the exception of one small tree near the left abutment of the downstream slope. No erosion or slumping was noted on the downstream slope. At the toe of the dam are several wet areas. These wet areas may be from poor surface drainage or from minor amounts of water exiting from the toe. No flow was noted in any of these areas (See page A-12).

c. Appurtenant Structures. The reservoir level at the time of the inspection was at elevation 594.3. The emergency spillway crest is at elevation 600.0. The concrete weir appeared to be in good condition. The length of the concrete weir at elevation 600 appears to be shorter (750 feet) than the design length (800 feet). The concrete weir then slopes to elevation 605 (107 feet long). The emergency spillway exit channel appeared to be in good condition. The bottom and side slopes of the exit channel are grassed. Near the end of the emergency spillway exit channel, a large amount of stone was placed when a high discharge in 1975 eroded part of the bottom of the discharge channel. This dumped rock probably would not restrict flow significantly.

The condition of the two 36" drainlines was unobserved during the inspection. The concrete control tower appeared to be in good condition. The discharge end of the pipes and the valve house appeared to be in good condition. The valve house is kept locked at all times. Operation of the valves is controlled at the power plant, however, the valves can be operated manually in the valve house.

d. Reservoir Area. The watershed is covered mostly with farmland. The reservoir slopes are gentle and are not susceptible to massive landslides which would affect the storage volume of the reservoir or overtopping of the dam by displacing water.

e. Downstream Channel. The channel downstream of Lake Chillisquaque is wide and gentle. The first structure to be affected by flood flows or failure of the dam would be the visitors center and curators home for the Montour Wildlife Preserve. Several additional homes are located in the flood plain between the dam and the Montour Station.

3.2 Evaluation. In general, the embankment and appurtenant structures appear to be in good condition and well maintained. The wet areas at the toe of the dam should be examined during the normal inspections. The tree should be removed from the embankment.

Note: Considerable precipitation occurred prior to and during a portion of the inspection possibly contributing to the wet areas noted at the toe and also possibly obscuring any small volume seeps or isolated wet areas. Dry weather inspections by the owner are encouraged.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures. The reservoir is maintained at approximately elevation 594.0. Water is pumped from the Susquehanna River to Lake Chillisquaque to be used for emergency cooling water. Procedures to be utilized during flooding are outlined in section 1.2h.

4.2 Maintenance of Dam. No planned maintenance schedule is utilized. Maintenance of the dam is performed by Pennsylvania Power and Light personnel. Maintenance of the dam is considered good.

4.3 Maintenance of Operating Facilities. The valves are operated on an as needed basis. The valves should be operated and lubricated on a regularly scheduled basis. Maintenance of the operating facilities is considered fair.

4.4 Warning System in Effect. There is no warning system in effect to warn downstream residents of large spillway discharges or failure of the dam.

4.5 Evaluation. Maintenance of the dam is considered good. Maintenance of the operating facilities is considered fair. The valves should be operated and lubricated on a regular basis. There is no warning system in effect to warn downstream residents.

SECTION 5
HYDRAULICS AND HYDROLOGY

5.1 Evaluation of Features.

a. Design Data. Hydrologic and hydraulic information are contained in a report prepared by Ebasco. This data consists of an inflow hydrograph, spillway rating curves and area-capacity curves. The designer used the PMF (25 inches of rainfall for a 6 hour duration) as the design storm. Based on this amount of precipitation over the drainage area and using a unit triangular hydrograph, the peak inflow to the reservoir was determined to be 24,500 cfs. The total flood volume would be about 6,800 acre-feet. Design calculations indicate the emergency spillway can control this flood.

The designer's calculations appear to be adequate to meet the Corps of Engineers spillway guidelines.

b. Experience Data. The maximum flood to date was during September 1975 when the reservoir level reached elevation 601.6. The peak discharge through the emergency spillway during this flood was estimated at 4500 cfs.

c. Visual Observations. The spillway and spillway discharge channel appeared to be in good condition. The concrete on the spillway weir appears to be in good condition. The rock placed in the spillway exit channel should not retard flow significantly.

d. Overtopping Potential. Overtopping potential was investigated through the development of the probable maximum flood (PMF) for the watershed and the subsequent routing of the PMF and fractions of the PMF through the reservoir and spillway.

The Corps of Engineers, Baltimore District, has directed that the HEC-1 Dam Safety Version systemized computer program be utilized. The program was prepared by the Hydrologic Engineering Center (HEC), U.S. Army Corps of Engineers, Davis, California, July 1978. The major methodologies or key input data for this program are discussed briefly in Appendix D.

5.2 Evaluation Assumptions. To enable us to complete the hydraulic and hydrologic analysis for this structure, it was necessary to make the following assumptions.

1. The water level in the reservoir prior to flood was at normal pool elevation 594.0.
2. No flow through the 36" pipe was assumed.

5.3 Summary of Overtopping Analysis. Complete summary sheets from the computer output are presented in Appendix D.

Peak inflow - 11,182 cfs
Spillway capacity - 29,022 cfs

a. Spillway Adequacy Rating. The Spillway Design Flood (SDF) for this dam is the PMF. The SDF is based on the hazard and size classification of the dam. Based on the following definition provided by the Corps of Engineers, this spillway is rated as adequate as a result of our hydrologic analysis.

Adequate - For intermediate size dams which pass the PMF.

The spillway and reservoir are capable of controlling the PMF without overtopping the embankment.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations. No signs of slumping, erosion or instability were noted during the inspection. The wet area at the toe of the dam should be watched for significant changes.

b. Design and Construction Data. Stability analysis calculated for design of the dam indicated a safety factor of 1.72 for steady seepage conditions with reservoir water level at elevation 600. For rapid drawdown conditions, a safety factor on 1.17 was calculated. See Figure 5 for design assumptions. The stability analyses performed for this structure appear to be adequate.

c. Operating Records. Good operating records are maintained on the reservoir water level. Operating records do not indicate any structural instability.

d. Post-Construction Changes. There have been no post-construction changes to the dam.

e. Seismic Stability. The dam is located in seismic zone 1. No seismic stability analysis has been performed. Normally, it can be considered that if a dam in this zone is stable under static loading conditions, it can be assumed safe for any expected earthquake loading. Because of the low risk of seismic activity and the adequate static analyses, no seismic analysis is necessary.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS/REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety. The dam appears to be in good condition. The visual observations, review of available information, hydrologic calculations and past operational performance indicate that Lake Chillisquaque's spillway is adequate. The spillway is capable of controlling the PMF without overtopping. Adequate stability analyses have been performed for the design of the structure.

b. Adequacy of Information. Sufficient information is available to complete a Phase I Report.

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

d. Necessity for Further Investigation. No further investigations are required at this time.

7.2 Recommendations/Remedial Measures

1. Continue to remove all trees from the embankment.
2. The wet areas at the toe of the embankment should be examined during the routine inspections. Drainage from these areas should be provided and flow monitored when it exists.
3. A formal inspection program should be instituted.
4. A warning system should be instituted to warn downstream residents of large spillway discharges or failure of the dam.
5. Valves should be operated and lubricated on a regularly scheduled basis.

APPENDIX A

CHECKLIST, VISUAL INSPECTION, PHASE I

CHECK LIST
VISUAL INSPECTION
PHASE I

NAME OF DAM Lake Chillisquaque COUNTY Montour STATE Pennsylvania ID# PA-815
TYPE OF DAM Earthfill HAZARD CATEGORY High
DATE(S) INSPECTION May 23, 1979 WEATHER Rainy TEMPERATURE 60°
POOL ELEVATION AT TIME OF INSPECTION 594.3 M.S.L. TAILWATER AT TIME OF INSPECTION None M.S.L.

INSPECTION PERSONNEL:

R. Jeffrey Kimball, L. Robert Kimball and Associates
James T. Hockensmith, L. Robert Kimball and Associates
Kuang-hwei Chuang, L. Robert Kimball and Associates
Don Werley, Pennsylvania Power and Light Company
Andy Spear, Pennsylvania Power and Light Company

James T. Hockensmith RECORDER

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None noted.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Horizontal alignment appears to be good. Vertical alignment - all elevations higher than design height.	
RIPRAP FAILURES	None.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
VEGETATION	One tree located on downstream slope near left abutment.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Appear to be good.	
ANY NOTICEABLE SEEPAGE	No seepage noted. Several wet areas noted at toe of dam.	
STAFF GAUGE AND RECORDER	Constant readings at Montour Power Plant of reservoir level and discharges.	
DRAINS	None.	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	N/A	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	N/A	
DRAINS	N/A	
WATER PASSAGES	N/A	
FOUNDATION	N/A	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	N/A	
STRUCTURAL CRACKING	N/A	
VERTICAL AND HORIZONTAL ALIGNMENT	N/A	
MONOLITH JOINTS	N/A	
CONSTRUCTION JOINTS	N/A	
STAFF GAUGE OR RECORDER	N/A	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Two 36" steel drain lines unobserved during the inspection except at the discharge end which appeared to be good.	
INTAKE STRUCTURE	Intake structure appears to be in good condition.	
OUTLET STRUCTURE	Outlet structure appears to be in good condition.	
OUTLET CHANNEL	Good condition.	
EMERGENCY GATE	Unobserved during the inspection.	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Concrete weir in good condition.	
APPROACH CHANNEL	Weathered shale appears to be in good condition.	
DISCHARGE CHANNEL	Open cut with grassed bottom and side slopes. Good condition.	
BRIDGE AND PIERS	None.	

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	N/A	
APPROACH CHANNEL	N/A	
DISCHARGE CHANNEL	N/A	
BRIDGE AND PIERS	N/A	
GATES AND OPERATION EQUIPMENT	N/A	

DOWNSTREAM CHANNEL

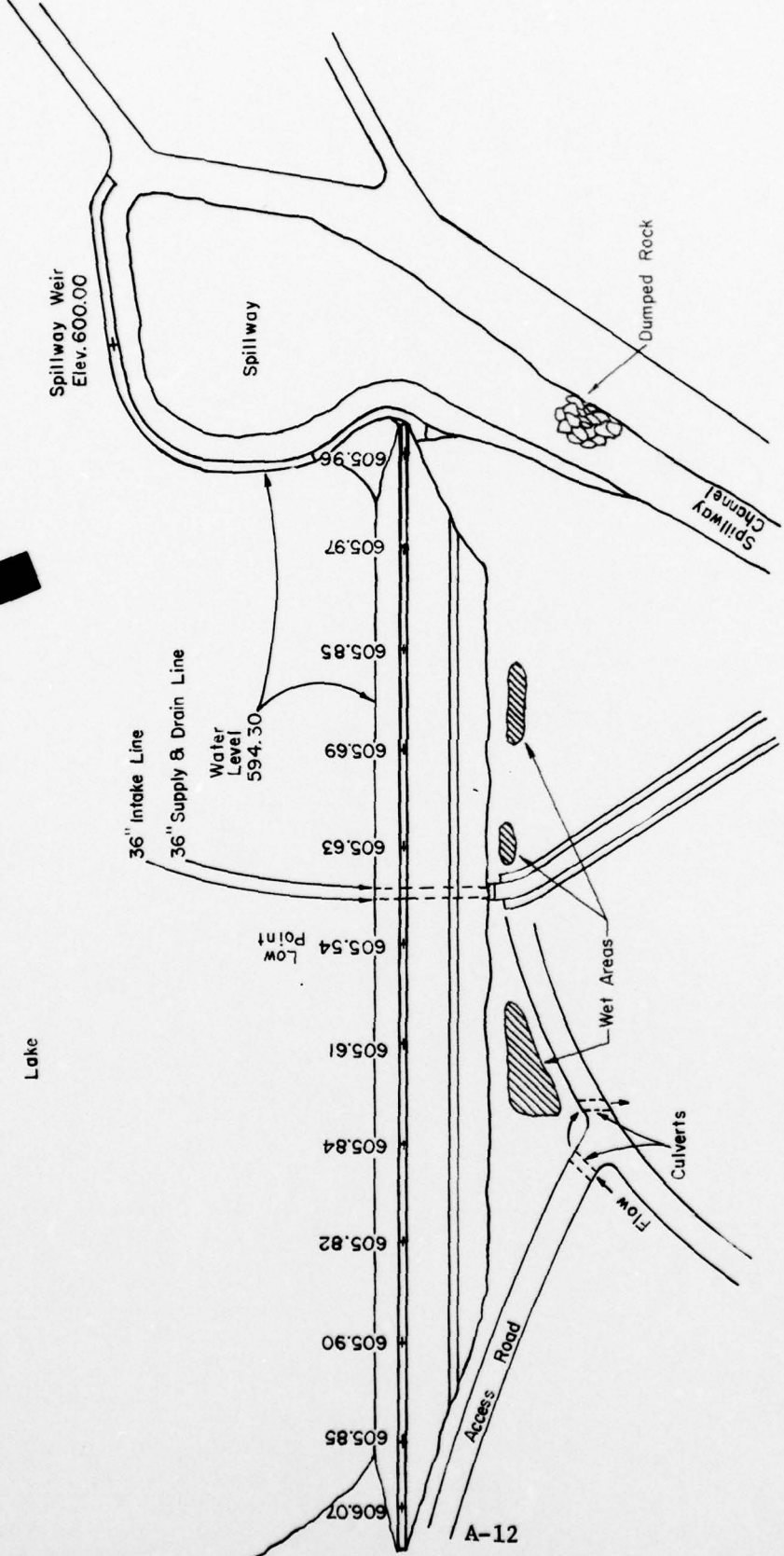
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Very wide and flat. No obstructions noted.	
SLOPES	Stable.	
APPROXIMATE NO. OF HOMES AND POPULATION	Approximately four homes between toe of dam and Montour Station - 16 people. Variable numbers of people are at the visitors center and at the power plant.	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Gentle, stable.	
SEDIMENTATION	Does not appear to be excessive.	

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None.	
OBSERVATION WELLS	None.	
WEIRS	None.	
PIEZOMETERS	None.	
OTHER	None.	



CHILLISQUAQUE DAM
Scale: 1" = 300'



A-12

APPENDIX B

CHECKLIST, ENGINEERING DATA, DESIGN, CONSTRUCTION, OPERATION, PHASE I

**CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I**

NAME OF DAM Lake Chillisquaque

ID# PA-815

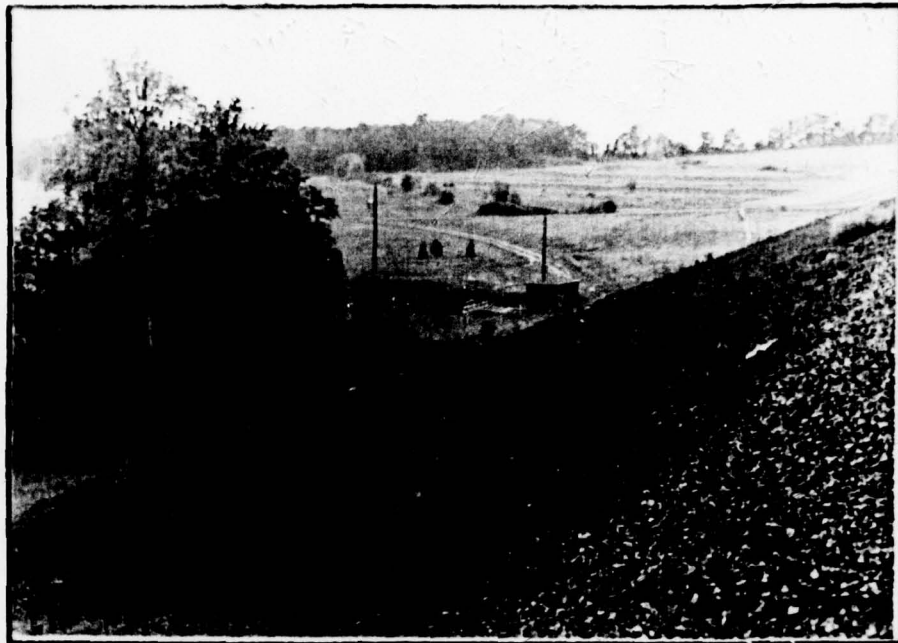
ITEM	REMARKS
AS-BUILT DRAWINGS	None.
REGIONAL VICINITY MAP	U.S.G.S. quadrangle and construction drawings.
CONSTRUCTION HISTORY	DER files and Pennsylvania Power and Light files.
TYPICAL SECTIONS OF DAM	Construction drawings.
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS RAINFALL/RESERVOIR RECORDS	Construction drawings. Pennsylvania Power and Light Company, Montour Station.

ITEM	REMARKS
DESIGN REPORTS	Ebasco design reports.
GEOLOGY REPORTS	Ebasco reports.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Ebasco reports and construction drawings.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Construction drawings and Pennsylvania Power and Light Company records.
POST-CONSTRUCTION SURVEYS OF DAM	None.
BORROW SOURCES	Construction drawings.

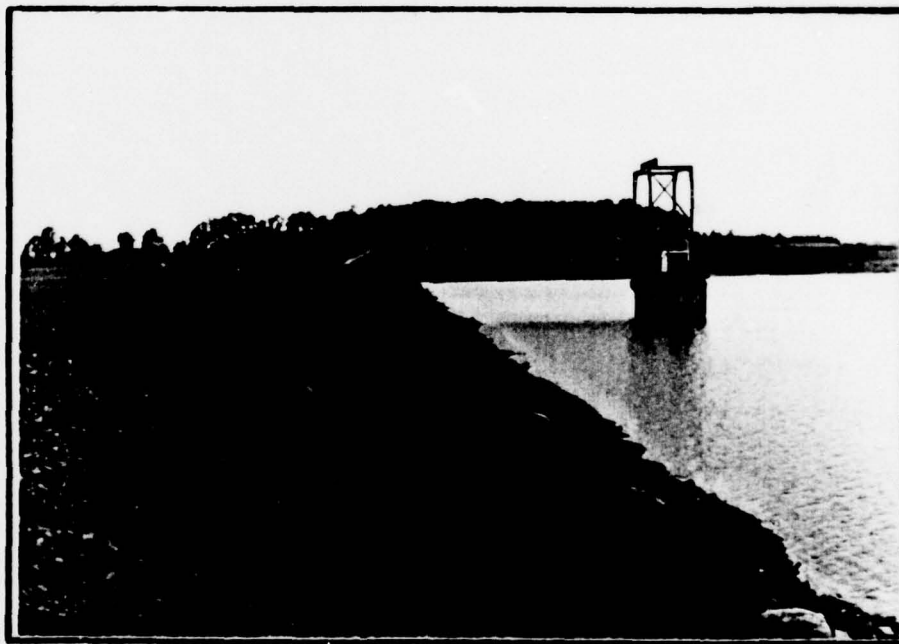
ITEM	REMARKS
MONITORING SYSTEMS	None.
MODIFICATIONS	None.
HIGH POOL RECORDS	Pennsylvania Power and Light Company, Montour Station.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None.
MAINTENANCE OPERATION RECORDS	Pennsylvania Power and Light Company, Montour Station.

ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	Construction drawings.
OPERATING EQUIPMENT PLANS & DETAILS	Construction drawings.

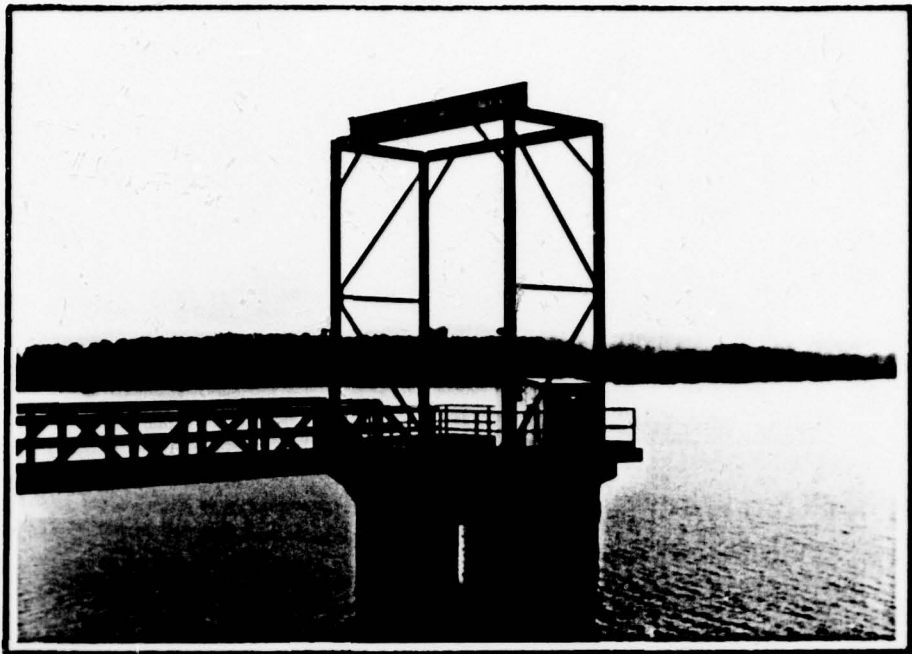
APPENDIX C
PHOTOGRAPHS



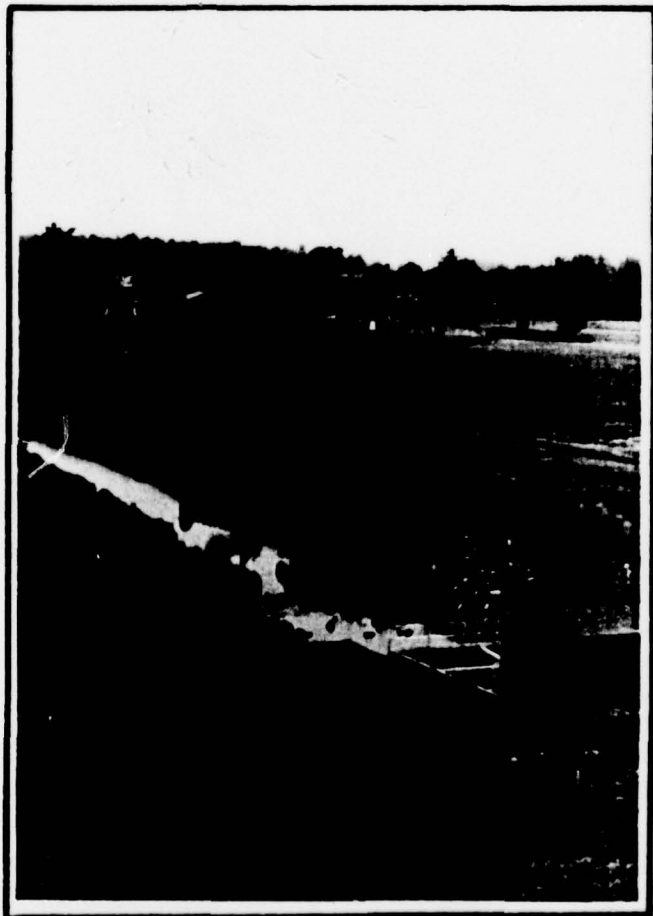
Downstream Slope. Note valve house at toe.



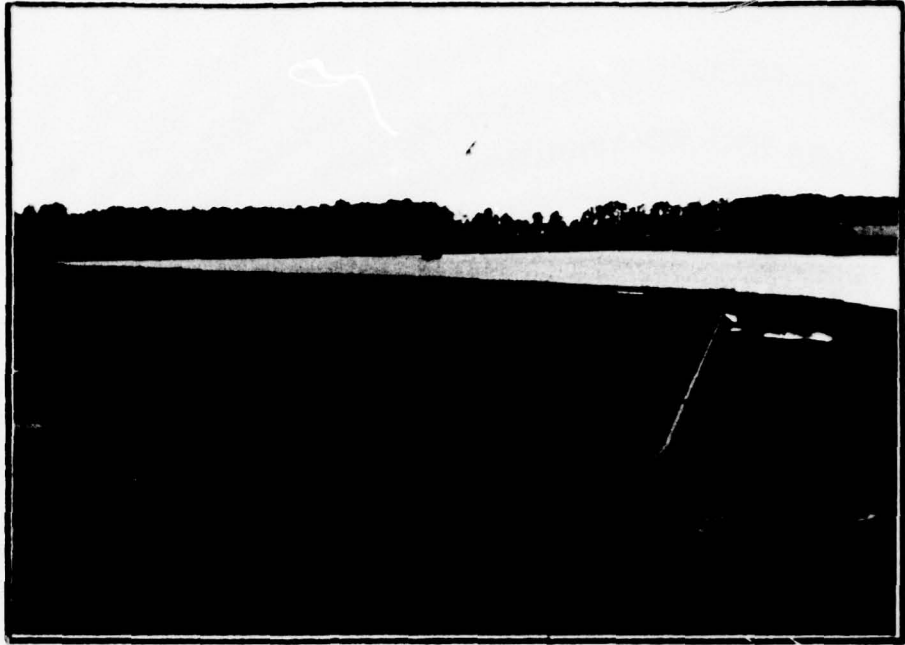
Upstream Slope. Note control tower.



Close-up of control tower.



Immediate downstream exposure.



Spillway weir on left abutment.



Spillway discharge channel.



Wet area at downstream toe.



Residence along stream downstream of dam.

APPENDIX D
HYDROLOGY AND HYDRAULICS

APPENDIX D
HYDROLOGY AND HYDRAULICS

Methodology. The dam overtopping and breach analyses were accomplished using the systemized computer program HEC-1 (Dam Safety Investigation), September, 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. A brief description of the methodology used in the analysis is presented below.

1. Precipitation. The Probable Maximum Precipitation (PMP) is derived and determined from regional charts prepared from past rainfall records including "Hydrometeorological Reports No. 40 prepared by the National Weather Service.

The index rainfall is reduced from 10% to 20% depending on watershed size by utilization of what is termed the HOP Brook adjustment factor. Distribution of the total rainfall is made by the computer program using distribution methods developed by the Corps.

2. Inflow Hydrograph. The hydrologic analysis used in development of the overtopping potential is based on applying a hypothetical storm to a unit hydrograph to obtain the inflow hydrograph for reservoir routing.

The unit hydrograph is developed using the Snyder method. This method requires calculation of several key parameters. The following list gives these parameters their definition and how they were obtained for these analysis.

Parameter	Definition	Where Obtained
C_t	Coefficient representing variations of watershed slope and storage	From Corps of Engineers*
L	Length of main stream channel miles	From U.S.G.S. 7.5 minute topographic
L_{ca}	Length on main stream to centroid of watershed	From U.S.G.S. 7.5 minute topographic
C_p	Peaking coefficient	From Corps of Engineers*
A	Watershed size	From U.S.G.S. 7.5 minute topographic

*Developed by the Corps of Engineers on a regional basis for Pennsylvania.

3. Routing. Reservoir routing is accomplished by using Modified Plus routing techniques where the flood hydrograph is routed through reservoir storage. Hydraulic capacities of the outlet works, spillways and the crest of the dam are used as outlet controls in the routing.

The hydraulic capacity of the outlet works can either be calculated and input or sufficient dimensions input and the program will calculate an elevation discharge relationship.

Storage in the pool area is defined by an area - elevation relationship from which the computer calculates storage. Surface areas are either planimetered from available mapping or U.S.G.S. 7.5 minute series topographic maps or taken from reasonably accurate design data.

4. Dam Overtopping. Using given percentages of the PMF the computer program will calculate the percentage of the PMF which can be controlled by the reservoir and spillway without the dam overtopping.

5. Dam Breach and Downstream Routing. The computer program is equipped to determine the increase in downstream flooding due to failure of the dam caused by overtopping. This is accomplished by routing both the pre failure peak flow and the peak flow through the breach (calculated by the computer with given input assumptions) at a given point in time and determining the water depth in the downstream channel. Channel cross-sections taken from U.S.G.S. 7.5 minute topographic maps were used in the downstream flood wave routing. Pre and post failure water depths are calculated at locations where cross-sections are input.



L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

DAM NAME CHILLISQUAQUE DAM

I.D. NUMBER PL. 47-8

SHEET NO. 1 OF 2

BY OTM DATE 6-26-79

CHILLISQUAQUE DAM

DRAINAGE AREA

AREA = 5.6 MI² (FROM U.S.G.S. 7.5-MIN. QUAD AND DER FILE)

UNIT HYDROGRAPH PARAMETERS

DAM SITE LOCATED IN ZONE #17, SUSQUEHANNA RIVER BASIN. FROM CORPS OF ENGINEERS, BALTIMORE DISTRICT REGIONAL STUDY.

$C_p = 0.45$, $C_t = 1.13$

$L = 5.0 \text{ MI}$, $L_{ca} = 1.67 \text{ MI}$ (U.S.G.S. 7.5-MIN. QUAD.)

$t_p = C_t (L \times L_{ca})^{0.3} = 1.13 (5 \times 1.67)^{0.3}$

$t_p = 2.14 \text{ HRS.}$ (SNYDERS LAG (t_p) IN HRS.)

LOSS RATE AND BASE FLOW PARAMETERS

AS RECOMMENDED BY CORPS OF ENGINEERS, BALTIMORE DISTRICT.

STRTL = 1 INCH

CNSTL = 0.05 IN/HR.

STRTQ = 1.5 CFS/MI²

QRCSN = 0.05 (5% OF PEAK FLOW)

RTIOR = 2.00

PROBABLE MAXIMUM STORM

FROM HR. NO. 40

P.M.P., INDEX RAINFALL = 22.2 (0.99) = 22.0 IN.

$R_6 = 117\%$, $R_{12} = 127\%$, $R_{24} = 136\%$, $R_{48} = 143\%$, $R_{72} = 145\%$



L ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

DAM NAME CHILLISQUAQUE DAM
I.D. NUMBER PA. 47-8
SHEET NO. 2 OF 2
BY OTM DATE 6-26-79

ELEVATION - CAPACITY RELATIONSHIP

FROM DESIGN DATA, DER FILE.

ELEVATION (FT.)	STORAGE (AC. FT.)
560	0
584	1000
593	2000
594	2250
595	2500
598	3000
600	3350
601	3500
603	4000
605.5	4450

DISCHARGE RATING CURVE

DETERMINED BY HEC-1.

SPILLWAY CREST AT ELEV. 600.0'

LENGTH OF CREST = 750'

COEFFICIENT OF DISCHARGE = 3.0 (BROAD CREST)

OVERTOPPING PARAMETERS

TOP OF DAM AT ELEV. 605.5'

LENGTH OF DAM EXCLUDING SPILLWAY = 2000'

COEFFICIENT OF DISCHARGE = 3.0 (BROAD CREST)

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 5.6 square miles, farmland, gentle slopes

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 594.0 (2200 acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 600.0 (3300 acre-feet)

ELEVATION MAXIMUM DESIGN POOL: 604.5

ELEVATION TOP DAM: 605.5

SPILLWAY CREST:

- a. Elevation 600
- b. Type Uncontrolled with concrete weir
- c. Width One foot
- d. Length 750 feet
- e. Location Spillover Right abutment.
- f. Number and Type of Gates None.

OUTLET WORKS:

- a. Type Two 36" steel pipes
- b. Location Through dam
- c. Entrance inverts 552.5
- d. Exit inverts 551.4
- e. Emergency draindown facilities Sluice gate in control tower

HYDROMETEOROLOGICAL GAUGES:

- a. Type Continuous recorder of pool level
- b. Location _____
- c. Records _____

MAXIMUM NON-DAMAGING DISCHARGE: September, 1975, elevation 601.6, estimated discharge 4500 cfs.

FLOOD HYDROGRAPH PACKAGE (MCC-1)
DAM SAFETY VERSION (MAY 1978)

LAST MODIFICATION 20 FEB 79

RUN DATE 09/07/81
TIME 00:28:00

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
TO CRITICAL HYDRAULIC ANALYSIS OF SAFETY OF CHILLISQUAGUE DAM
INITIATED BY PM ROUTED THROUGH THE RESERVOIR PG 17-8

JOB SPECIFICATION
NO. NHR MMIN IDAY IHR IMIN METRC IPLT IPRT NSTAN
228 0 15 0 0 0 0 0 0 0 0

MULTI-PLAN ANALYSES TO BE PERFORMED

PLAN-1 NR10-2.1810

PLAN-2 NR10-2.1810

PLAN-3 NR10-2.1810

PLAN-4 NR10-2.1810

PLAN-5 NR10-2.1810

PLAN-6 NR10-2.1810

PLAN-7 NR10-2.1810

PLAN-8 NR10-2.1810

PLAN-9 NR10-2.1810

PLAN-10 NR10-2.1810

HYDROGRAPH DATA

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

TRSDA 9.40 TRSPE 0.00 TRSPE RATIO 0.000 ISNOW 0.00 LOCAL 0.00
 TRSPE COMPUTED BY THE PROGRAM IS 0.00

PRECIP DATA
 SPCF PMS B6 R12 B2A B48 R72 B94
 28.00 117.00 187.00 196.00 149.00 145.00 0.00

LOSS DATA
 LROPT STRKR OLTR RTIOL ERAIN STRKS RTIOK STRTL CNSTL ALXMA RTIMP
 0 0.00 0.00 11.00 0.00 0.00 1.00 1.00 0.00 0.00 0.00

RECESSON DATA
 SIRIO = -1.50 ORCSN = RTIOR = 2.00
 APPROXIMATE CORRECTIONS FROM GIVEN INTERVALS AND TR ARE 1.5, 0.0, AND 2.1, 0.1 INTERVALS

NO.	DATE	RAIN	LOSS	FLOW	HR,MM	PERIOD	RAIN	LOSS	COMP G
1.01	0.15	0.00	0.00	8.	1.02	12.15	148	.51	.50
1.01	0.30	0.00	0.00	7.	1.02	12.30	146	.51	.50
1.01	0.45	0.00	0.00	7.	1.02	12.45	147	.51	.50
1.01	1.00	0.00	0.00	6.	1.02	13.00	148	.51	.50

100	317	314	293	274	255	239	222	207	193
100	187	187	174	171	158	149	141	134	127
90	84	79	73	68	64	60	56	52	48
45	42	39	37	34	32	30	28	26	24
27	24	22	20	18	17	16	15	14	13
15	14	13	12	11	10	10	9	9	8
PEAK									
CFS	11382	8586	3345	1149	331005	TOTAL VOLUME			
CMS	317	237	95	33	2273				
INCHES	1426	2233	2291	2291	2291				
MM	36213	56454	58192	58192	58192				
FEET	2287	6255	6229	6229	6229				
THOUS CU M	5252	8184	8436	8436	8436				

HYDROGRAPH ROUTING

15TAQ	2	1	0	0	0	0	1	0	0
15CON	0	0	0	0	0	0	0	0	0
15JPT	0	0	0	0	0	0	0	0	0
15NAME	0	0	0	0	0	0	0	0	0
15ISTAGE	0	0	0	0	0	0	0	0	0
15AUTO	0	0	0	0	0	0	0	0	0

LOSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FLOSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INER	1	1	1	1	1	1	1	1	1
ROUTING DATA	1001	1001	1001	1001	1001	1001	1001	1001	1001
LAG	0	0	0	0	0	0	0	0	0
AMSK	0	0	0	0	0	0	0	0	0
NSDCL	0	0	0	0	0	0	0	0	0
NSDLS	0	0	0	0	0	0	0	0	0
NSDLS	0	0	0	0	0	0	0	0	0
LAG	0	0	0	0	0	0	0	0	0
AMSK	0	0	0	0	0	0	0	0	0
NSDCL	0	0	0	0	0	0	0	0	0
NSDLS	0	0	0	0	0	0	0	0	0
NSDLS	0	0	0	0	0	0	0	0	0
LAG	0	0	0	0	0	0	0	0	0
AMSK	0	0	0	0	0	0	0	0	0
NSDCL	0	0	0	0	0	0	0	0	0
NSDLS	0	0	0	0	0	0	0	0	0
NSDLS	0	0	0	0	0	0	0	0	0
LAG	0	0	0	0	0	0	0	0	0
AMSK	0	0	0	0	0	0	0	0	0
NSDCL	0	0	0	0	0	0	0	0	0
NSDLS	0	0	0	0	0	0	0	0	0
NSDLS	0	0	0	0	0	0	0	0	0
LAG	0	0	0	0	0	0	0	0	0
AMSK	0	0	0	0	0	0	0	0	0
NSDCL	0	0	0	0	0	0	0	0	0
NSDLS	0	0	0	0	0	0	0	0	0
NSDLS	0	0	0	0	0	0	0	0	0
LAG	0	0	0	0	0	0	0	0	0
AMSK	0	0	0	0	0	0	0	0	0
NSDCL	0	0	0	0	0	0	0	0	0
NSDLS	0	0	0	0	0	0	0	0	0
NSDLS	0	0	0	0	0	0	0	0	0
LAG	0	0	0	0	0	0	0	0	0
AMSK	0	0	0	0	0	0	0	0	0
NSDCL	0	0	0	0	0	0	0	0	0
NSDLS	0	0	0	0	0	0	0	0	0
NSDLS	0	0	0	0	0	0	0	0	0
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AMSK	0	0	0	0	0	0	0	0	0
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LAG	0	0	0	0	0	0	0	0	0
AMSK	0	0	0	0	0	0	0	0	0
NSDCL	0	0	0	0	0	0	0	0	0
NSDLS	0	0	0	0	0	0	0	0	0
NSDLS	0	0	0	0	0	0	0	0	0
LAG	0	0	0	0	0	0	0	0	0
AMSK	0	0	0	0	0	0	0	0	0
NSDCL	0	0	0	0	0	0	0	0	0
NSDLS	0	0	0	0	0	0	0	0	0
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AMSK	0	0	0	0	0	0	0	0	0
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AMSK	0	0	0	0	0	0	0	0	0
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NSDLS	0	0	0	0	0	0	0	0	0
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NSDLS	0	0	0	0	0	0	0	0	0
LAG	0	0	0	0	0				

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

OPERATION RATIO 9	STATION	AREA	PLAN	RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8
1100				.10	.20	.30	.40	.50	.60	.70	.80
HYDROGRAPH AT 11102		5460	1	1110	2236	3354	4473	5591	6709	7828	8946
11695		14101	1	316711	613311	950011	1264611	1682311	1892911	2216611	2532211
ROUTED TO 10692		3100	1	3100	6200	9300	12400	15500	18600	21700	24800
302.741		14901	1	0.0011	16.9611	64.1811	101.0911	137.5811	172.2711	205.7311	238.8711

SUMMARY OF DAM SAFETY ANALYSIS

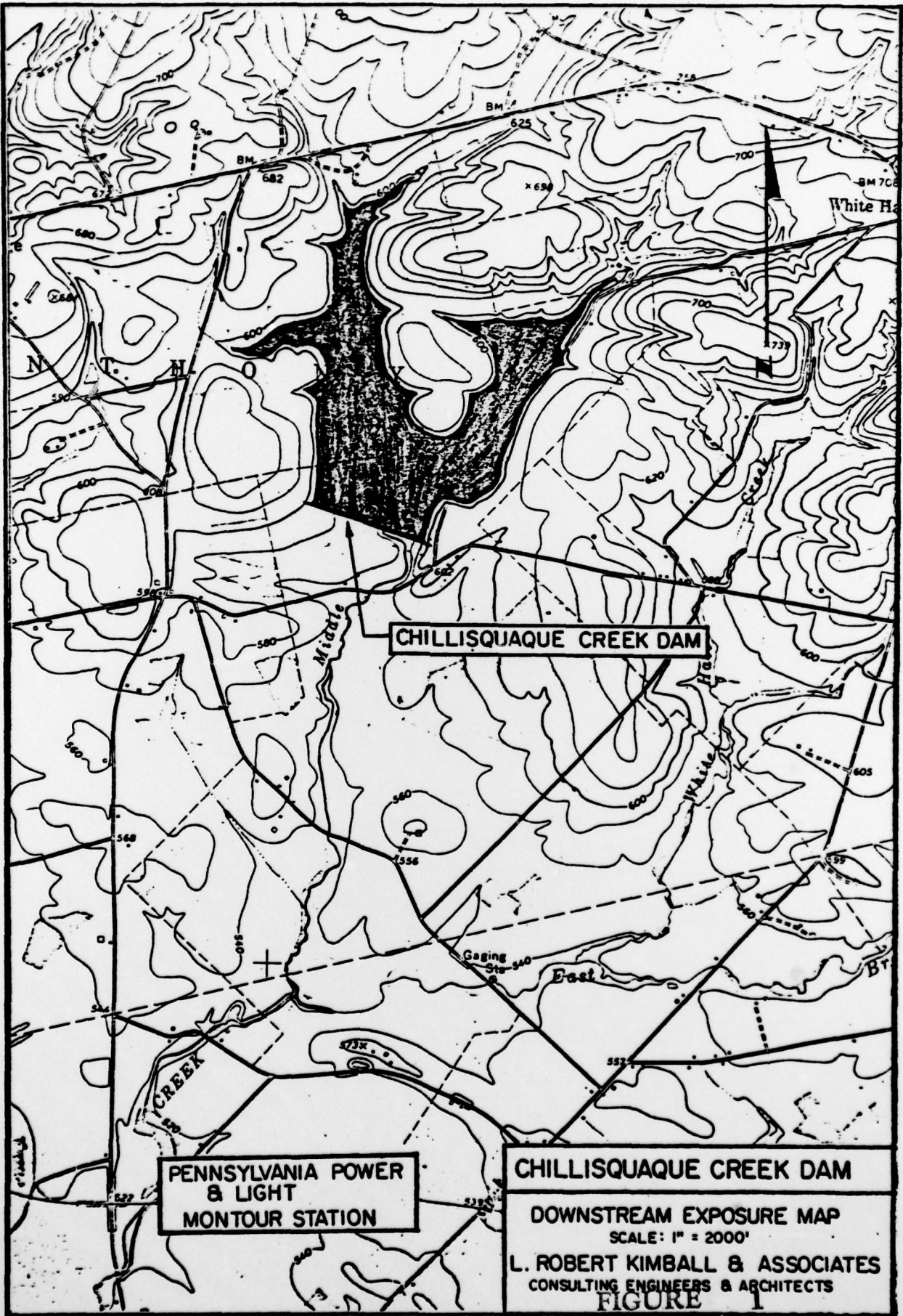
PLAN 1

ELEVATION INITIAL VALUE SPILLWAY CREST TOP OF DAM
 STORAGE 594.30 600.00 605.30
 OUTFLOW 2325 3350 4530
 0 0 29024

RATIO OF PPE	MAXIMUM RESERVOIR WATER ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.0	598.99	0.00	3007	0	0.00	0.00	0.00
.90	590.25	0.00	3477	659	0.00	47.25	0.00
.80	601.00	0.00	3501	2267	0.00	44.25	0.00
.70	601.26	0.00	3590	3568	0.00	43.75	0.00
.60	601.67	0.00	3657	4851	0.00	43.25	0.00
.50	601.94	0.00	3731	6074	0.00	42.00	0.00
.40	602.18	0.00	3796	7263	0.00	41.75	0.00
.30	602.34	0.00	3851	8431	0.00	41.75	0.00
1.00	602.93	0.00	3957	10692	0.00	42.50	0.00

APPENDIX E

DRAWINGS



CHILLISQUAQUE CREEK DAM

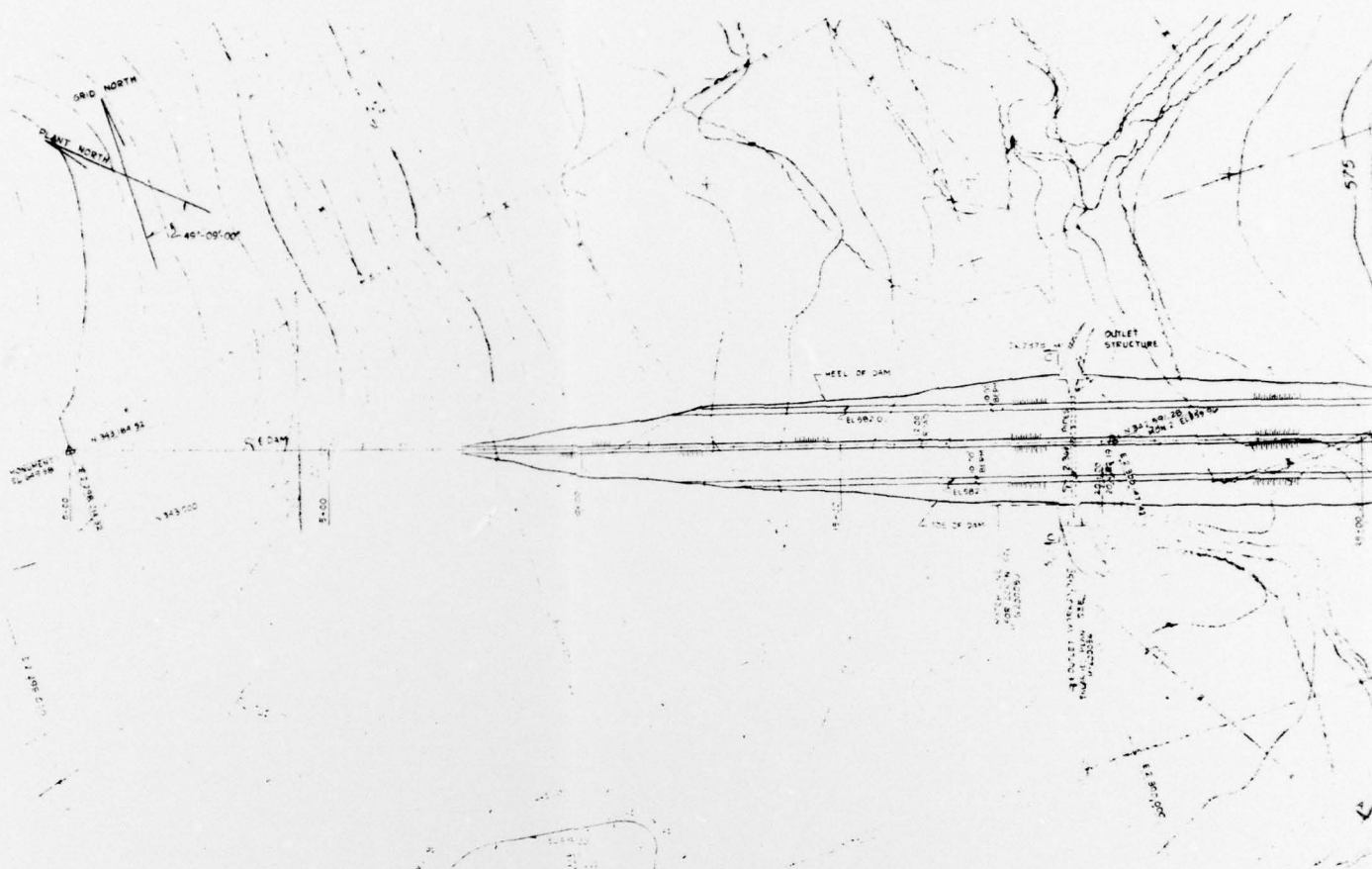
**PENNSYLVANIA POWER
& LIGHT
MONTOUR STATION**

CHILLISQUAQUE CREEK DAM

DOWNSTREAM EXPOSURE MAP
SCALE: 1" = 2000'

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS

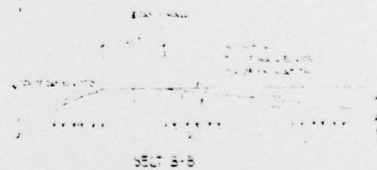
FIGURE 1
FIGURE 1



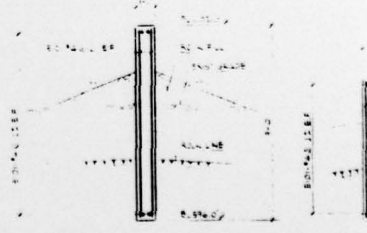
PLAN OF DAM & SPILLWAY



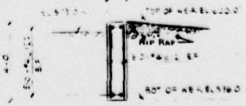
PLAN OF SPILLWAY CHANNEL
OUT OF ENLARGED
GEOMETRY



SECT B-B
1/4\"/>



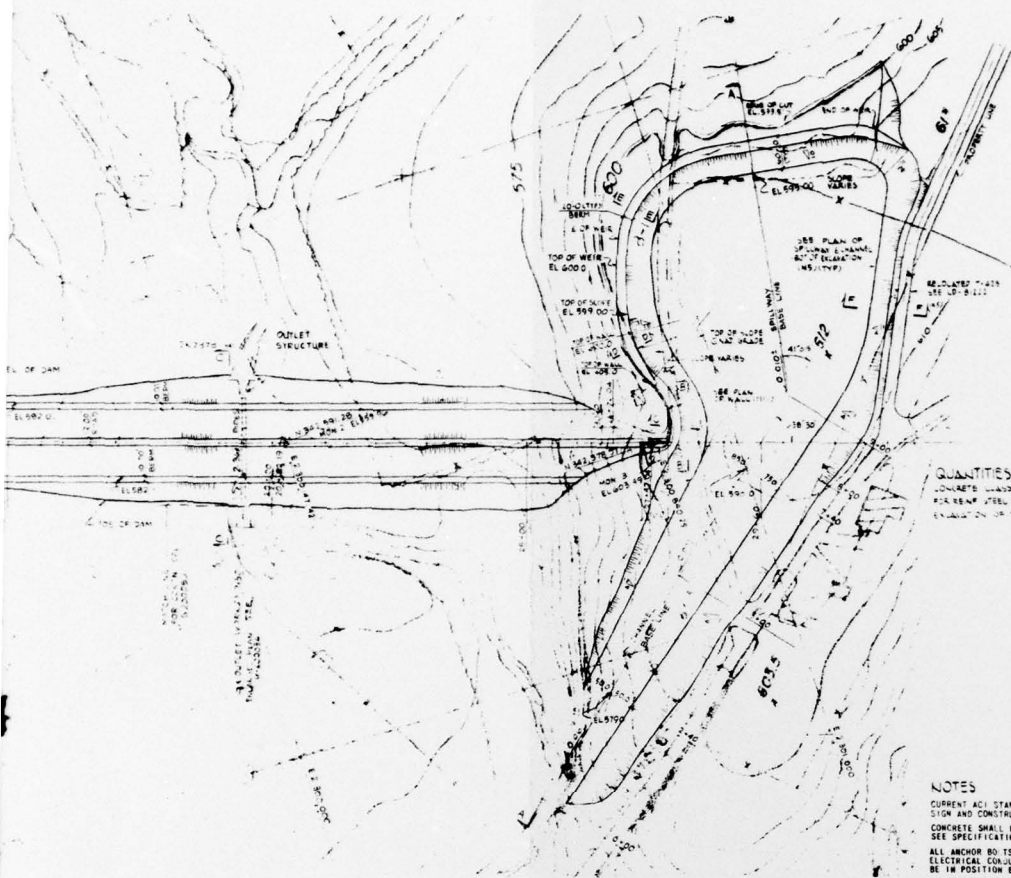
SECT C-C
1/4\"/>



SECT E-E
1/4\"/>

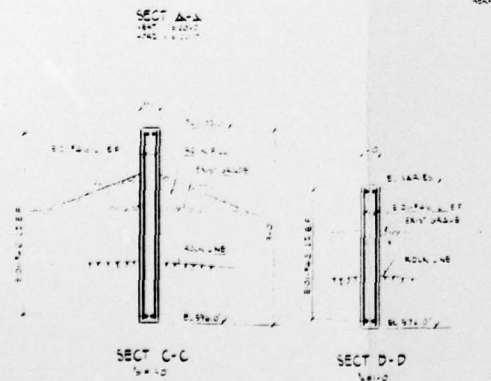
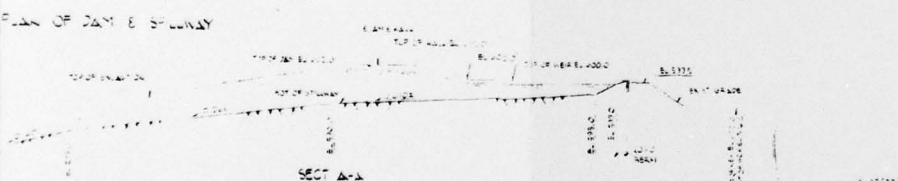
1

47-8-2
 APPROVED IN THE OFFICE OF THE WATER & POWER RESOURCES BOARD BY THE ASSISTANT COMMISSIONER OF FOREST & WATER ON THE 19th DAY OF OCTOBER 1972
John H. ...



QUANTITIES NET BY FIELD UNLESS NOTED
 CONCRETE CLASS B (2000 PSI)
 FOR REBAR STEEL SEE BAR BENDING SCHEDULE (B-1) AND B-2
 EXHAUSTION OF SPILLWAY CHANNEL

NOTES
 CURRENT ACI STANDARDS SHALL GOVERN FOR ALL DESIGN AND CONSTRUCTION UNLESS OTHERWISE NOTED.
 CONCRETE SHALL BE CLASS B (2000 PSI)
 SEE SPECIFICATION B-1 AND B-2
 ALL ANCHOR BOLTS, DRAIN PIPES, PIPE SLEEVES, ELECTRICAL CONDUITS AND EMBEDDED PARTS SHALL BE IN POSITION BEFORE CONCRETE IS PLACED.
 FOR SPECIFICATIONS FOR STEEL FOR CONCRETE REINFORCING BARS AND FOR BAR DETAILS SEE BAR BENDING SCHEDULE B-1 AND B-2
 PLACING DIMENSIONS ARE GIVEN TO CENTER OF BARS UNLESS NOTED.
 ALL SPLICES IN REINFORCEMENT SHALL COMPLY WITH THE REQUIREMENTS OF CURRENT ACI STANDARDS, SECTION 805, BUT IN NO CASE SHALL LAP BE LESS THAN 20 BAR DIAMETERS.
 ALL BARS SHALL HAVE 2" MINIMUM CONCRETE COVER UNLESS OTHERWISE NOTED.
 SHIFT OR BEND BARS TO CLEAR ANCHOR BOLTS, DRAIN PIPE SLEEVES AND EMBEDDED PARTS.



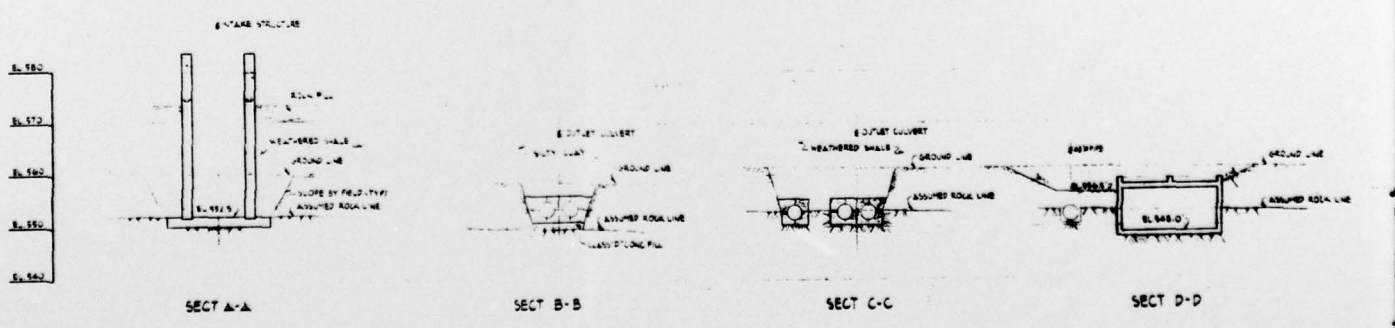
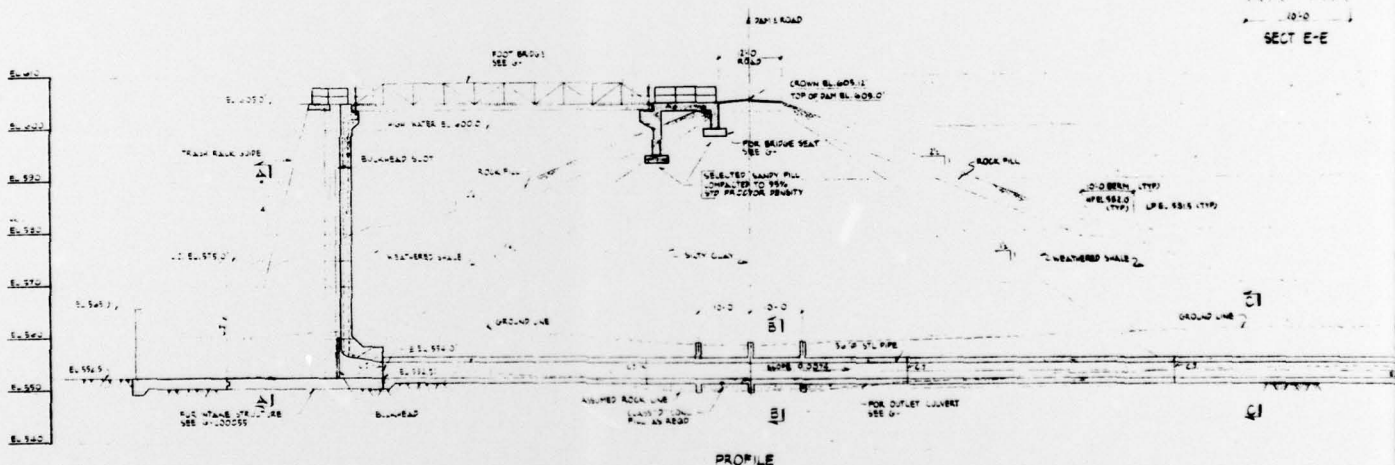
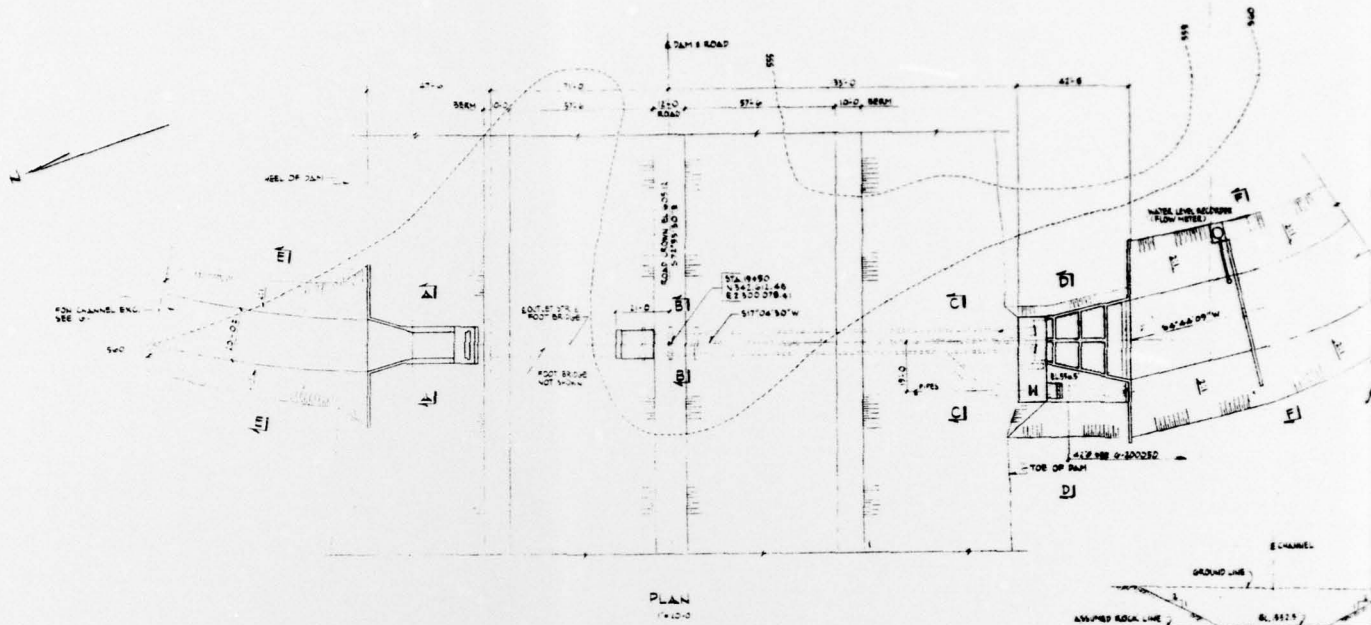
REFERENCE DRAWINGS
 B-1
 B-2
 B-3
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RESERVOIR PERMIT DWG 5
 PENNSYLVANIA POWER & LIGHT COMPANY
 MONTGOMERY STEAM ELECTRIC STATION
 1972 .0000 W. INSTALLATION ONLY NO.
 MAKE UP RESERVOIR DAM-PLAN
 EBASCO SERVICES INCORPORATED NEW YORK
 DATE: 10/19/72
 BY: J. BOGNA
 APPROVED: [Signature]
 G-100092

NO.	DATE	REVISION	BY	CHK.	APPROVED

2

L. ROBERT KIMBALL & ASSOCIATES
 CONSULTING ENGINEERS & ARCHITECTS
 FIGURE 2



1

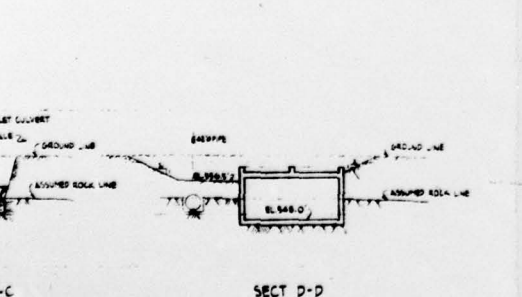
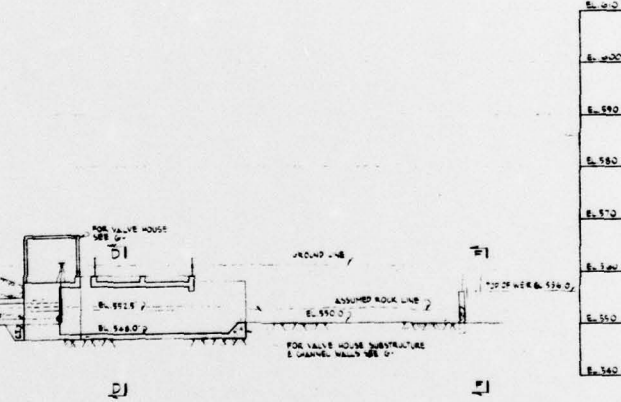
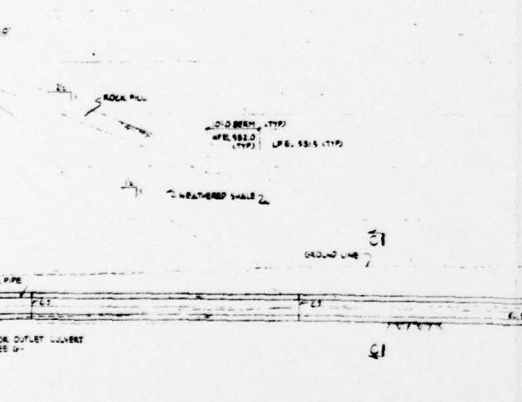
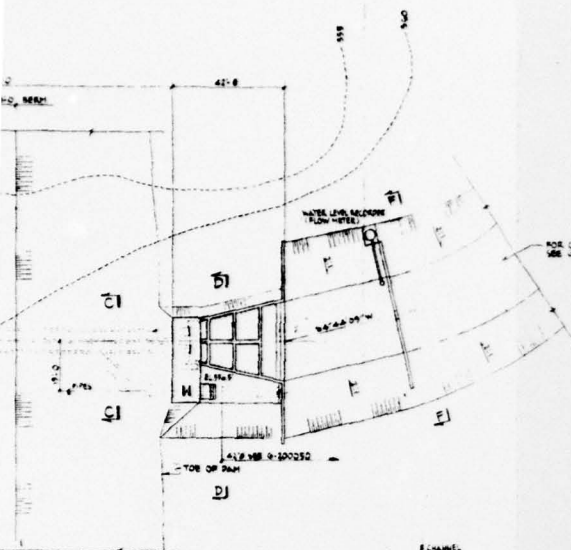
QUANTITIES
FOR QUANTITIES SEE APPROPRIATE DWG.

NOTES

DESIGNED BY	47-R-4
CHECKED BY	
DATE	

REFERENCE DRAWINGS

LIST OF DRAWING
NAME OF DRAWING: OUTLET STRUCTURE - TAKE-UP RESERVOIR
RESERVOIR TAKE-UP PRELIM. PLANT TAKE-UP
DATE: 01-22-66



SEP 20 1966
Johnston Lawrence

RESERVOIR PERMIT DWG NO. 7

PENNSYLVANIA POWER & LIGHT COMPANY
MONTGOMERY STEAM ELECTRIC STATION
1972 000498 INSTALLATION UNIT NO. 1
TAKE-UP RESERVOIR
OUTLET STRUCTURE - PLANS & SECTIONS - 1143

ESBSCO SERVICES INCORPORATED NEW YORK

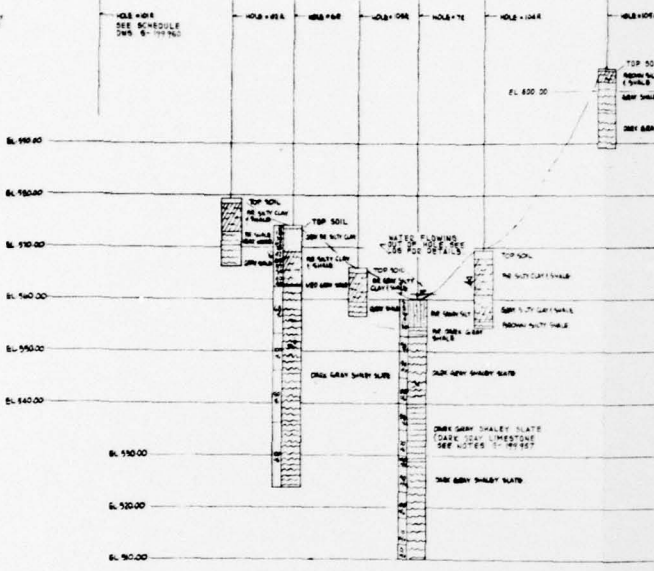
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NO. 200C54

2

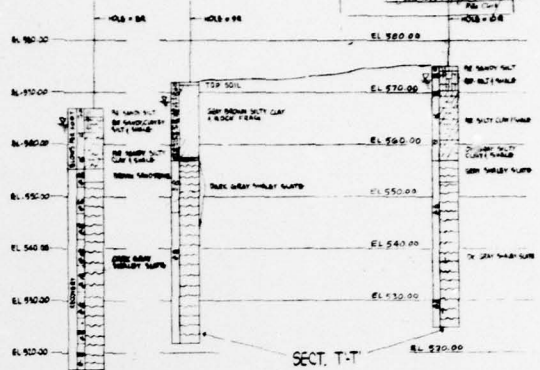
L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
FIGURE 3

P. MILLWAY
 EL. 520.00
 L. MILLWAY
 EL. 520.00
 P. MILLWAY
 EL. 520.00

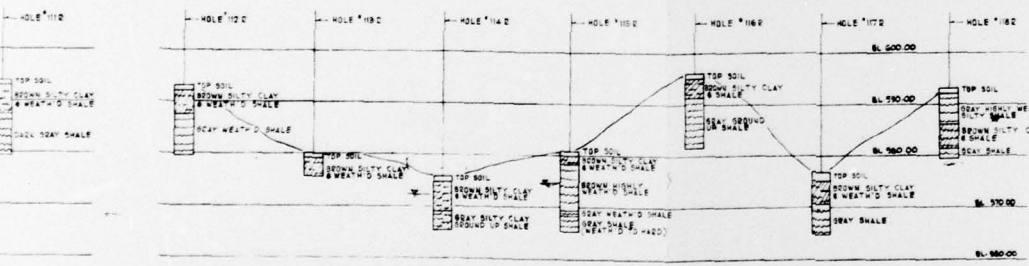
47-8-7
 SECTION OF THE WATER & POWER
 RESOURCES - DEPARTMENT OF FORESTS &
 WATERS ON THE DAY OF 10/18/47
 [Signature]



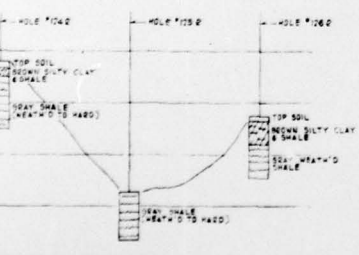
SECT. S-S



SECT. T-T



SECT. U - U

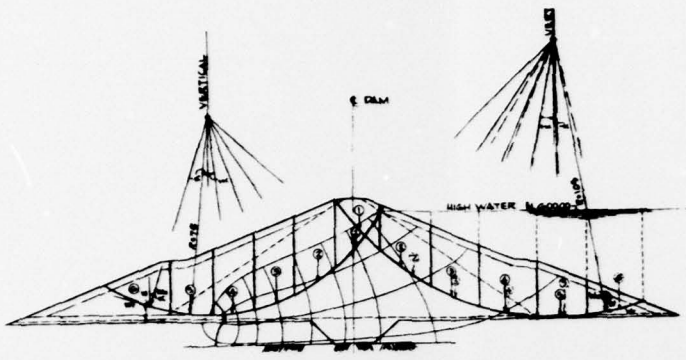


FOR LOCATIONS OF SECTS. & BORINGS SEE S-199551

RESERVOIR PERMIT DW6 NO. 3
 PENNSYLVANIA POWER & LIGHT COMPANY
 MONTGOUR STEAM ELECTRIC STATION
 (872 - 81,000 KW INSTALLATION - UNIT NO. 1)
 DAM - LONG SECTION & BORINGS
 ERABCO SERVICES INCORPORATED
 [Signature]
 SR 7876
 05/58

NO.	DATE	REVISION	BY	CHKD.

2



COMPLETE RAPID DRAINAGE U.S. SLOPE E-09 F₀ = 1.17

SLICE NO.	GEOMETRIC PROPERTIES						SLIP PROPERTIES						COMPLETE DRAINAGE					
	WIDTH FT.	HEIGHT FT.	AREA SQ.FT.	C	TAN φ	γ	C	TAN φ	γ	W	W _u	W _t	U	W _u	W _t	U		
1	17.0	10.4	177	47.0	7.31	1.08	24.0	15	26.0	50	12.0	114	20.1	18.7	14.7	5.6	8.1	2.2
2	20.0	21.0	420	35.4	5.81	1.14	25.0	15	26.0	50	12.0	124	24.4	21.8	20.1	18.7	3.7	3.7
3	20.0	24.2	485	25.4	5.99	1.17	26.0	15	26.0	50	12.0	124	26.2	23.2	20.2	18.7	7.0	7.0
4	20.0	22.8	452	12.4	1.82	1.09	24.0	15	26.0	50	12.0	124	24.4	21.8	18.7	18.7	9.6	9.6
5	20.0	18.8	375	-1.0	-0.17	1.09	25	26.0	50	12.0	124	24.4	21.8	18.7	18.7	15.0	15.0	15.0
6	20.0	7.8	167	10.5	1.82	1.09	25	26.0	50	12.0	124	24.4	21.8	18.7	18.7	6.3	6.3	6.3

$F_0 = \frac{\sum (W_u) \tan \phi + \sum (C_u)}{\sum (W_t) \tan \phi + \sum (C_t)} = \frac{41.8 + 1.17}{75.8} = 1.17$

STEADY SEEPAGE D.S. SLOPE E-10 F₀ = 1.17

SLICE NO.	GEOMETRIC PROPERTIES						SLIP PROPERTIES											
	WIDTH FT.	HEIGHT FT.	AREA SQ.FT.	C	TAN φ	γ	C	TAN φ	γ	W	W _u	W _t	U	W _u	W _t	U		
1	18.5	14.1	275	49.0	7.31	1.08	24.0	15	26.0	50	12.0	114	20.1	18.7	14.7	5.6	8.1	2.2
2	18.0	29.8	540	35.4	5.81	1.14	25.0	15	26.0	50	12.0	124	24.4	21.8	20.1	18.7	3.7	3.7
3	18.0	31.5	567	25.4	5.99	1.17	26.0	15	26.0	50	12.0	124	26.2	23.2	20.2	18.7	7.0	7.0
4	18.0	28.5	513	12.4	1.82	1.09	24.0	15	26.0	50	12.0	124	24.4	21.8	18.7	18.7	9.6	9.6
5	17.0	24.8	422	-1.0	-0.17	1.09	25	26.0	50	12.0	124	24.4	21.8	18.7	18.7	15.0	15.0	15.0
6	27.5	11.0	303	10.5	1.82	1.09	25	26.0	50	12.0	124	24.4	21.8	18.7	18.7	6.3	6.3	6.3

$F_0 = \frac{\sum (W_u) \tan \phi + \sum (C_u)}{\sum (W_t) \tan \phi + \sum (C_t)} = \frac{62.8 + 1.17}{54.0} = 1.17$

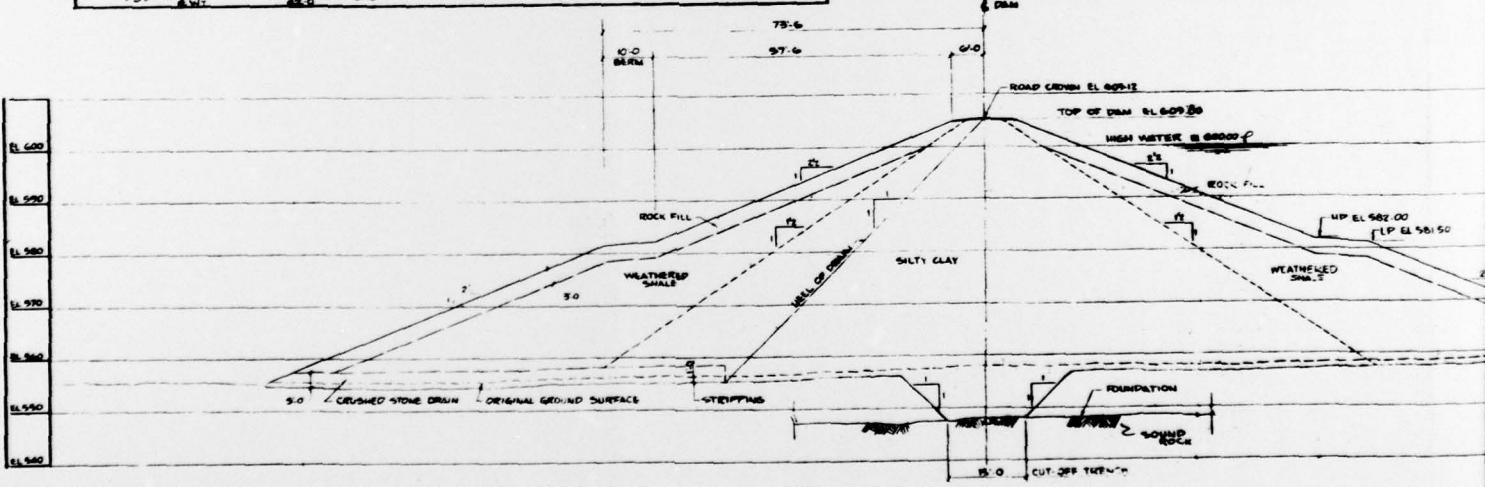
FULL POOL U.S. SLOPE E-105 F₀ = 3.18

SLICE NO.	VALUES FROM TABLE ABOVE						SOIL						WATER						SOIL + WATER					
	AREA SQ.FT.	HEIGHT FT.	AREA SQ.FT.	C	TAN φ	γ	W	W _u	W _t	U	W	W _u	W _t	U	W	W _u	W _t	U						
1	177	47.0	731	47.0	7.31	1.08	24.0	15	26.0	50	12.0	114	20.1	18.7	14.7	5.6	8.1	2.2						
2	420	35.4	1814	35.4	5.81	1.14	25.0	15	26.0	50	12.0	124	24.4	21.8	20.1	18.7	3.7	3.7						
3	485	25.4	1199	25.4	5.99	1.17	26.0	15	26.0	50	12.0	124	26.2	23.2	20.2	18.7	7.0	7.0						
4	452	12.4	682	12.4	1.82	1.09	24.0	15	26.0	50	12.0	124	24.4	21.8	18.7	18.7	9.6	9.6						
5	375	-1.0	-17	-1.0	-0.17	1.09	25	26.0	50	12.0	124	24.4	21.8	18.7	18.7	15.0	15.0	15.0						
6	167	10.5	182	10.5	1.82	1.09	25	26.0	50	12.0	124	24.4	21.8	18.7	18.7	6.3	6.3	6.3						

$F_0 = \frac{\sum (W_u) \tan \phi + \sum (C_u)}{\sum (W_t) \tan \phi + \sum (C_t)} = \frac{84.3 + 1.17}{26.5} = 3.18$

SOIL PROPERTIES

TYPE OF SOIL	DRY UNIT WEIGHT γ _d (LB/CF)	MOIST UNIT WEIGHT γ _m (LB/CF)	SATURATED UNIT WEIGHT γ _{sat} (LB/CF)	SUBMERGED UNIT WEIGHT γ _{sub} (LB/CF)	ANGLE OF INTERNAL FRICTION φ
COMPRESSED SILTY CLAY	100	110	125	25	15
COMPRESSED WEATHERED SHALES	110	120	132	22	25
ROCK FILL	100	—	120	20	—



SECTION C-C (600052, DM)
MAXIMUM SECTION
 1" = 10'

APPENDIX F

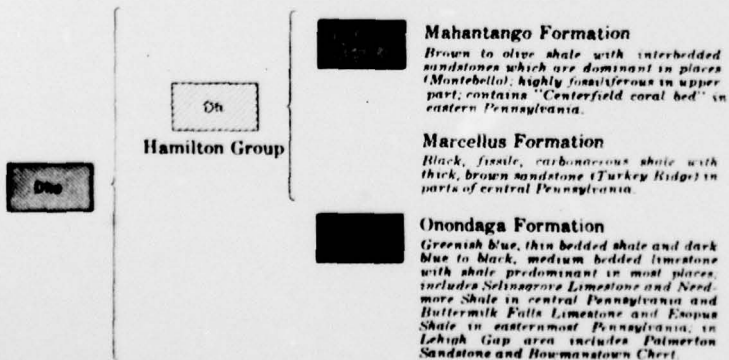
GEOLOGY

General Geology.

Lake Chillisquaque lies in the Valley and Ridge Physiographic Province of Fennemann (1938). This region in Eastern Pennsylvania is characterized by numerous synclinal and anticlinal features. Structurally, the dam lies near the axis of a large plunging anticlinal feature which plunges to the northeast. Major faulting is not noted in the area. The dam is underlain by Middle Ordovician aged sediments of the Mahantango Formation. This formation extends for a thickness of 1000 to 1500 feet. It is a brown to olive shale with interbedded sandstone. The upper members are highly fossiliferous.



GEOLOGIC MAP OF LAKE CHILLISQUAQUE DAM AREA



Scale: 1:250,000