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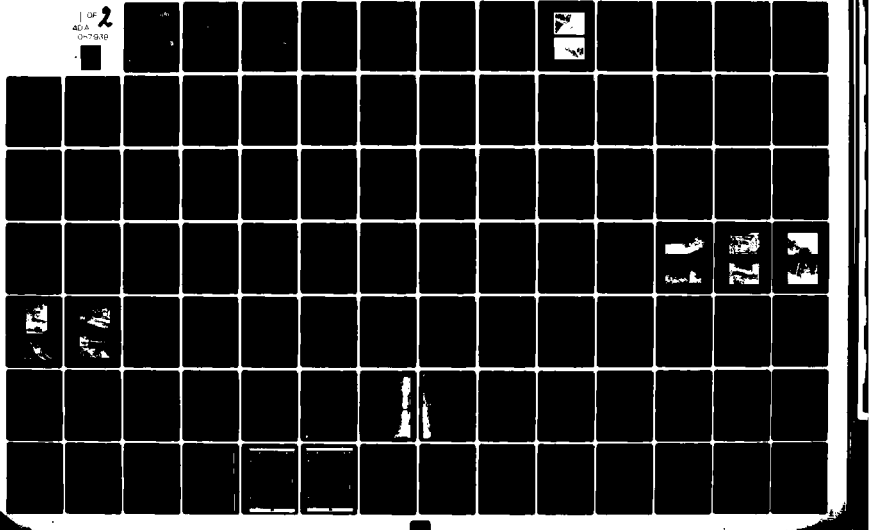


OHIO RIVER BASIN
WASHWATER RUN
FAYETTE COUNTY

LEVEL III

PENNSYLVANIA

NDI No. PA 00209
PENN DER No. 26-22

COLONIAL DAM No. 3

REDSTONE WATER COMPANY

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

ACKENHEIL & ASSOCIATES
DACW31-80-C-0026

REPARED FOR

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND 21203

BY

ACKENHEIL & ASSOCIATES GEO SYSTEMS, INC.
CONSULTING ENGINEERS
1000 BANKSVILLE ROAD
PITTSBURGH, PENNSYLVANIA 15216

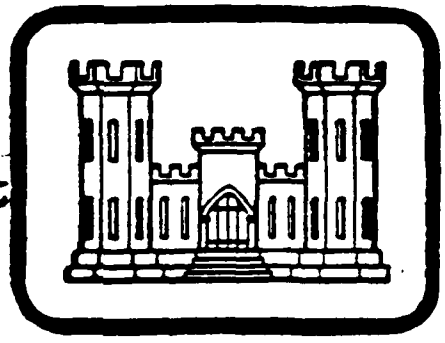
MAY 1980

OHIO RIVER BASIN

COLONIAL DAM NO. 3
FAYETTE COUNTY, COMMONWEALTH OF PENNSYLVANIA
NDI NO. PA 00209
PennDER No. 26-22

REDSTONE WATER COMPANY

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



Prepared for: DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

Prepared by: ACKENHEIL & ASSOCIATES GEO SYSTEMS, INC.
Consulting Engineers
1000 Banksville Road
Pittsburgh, Pennsylvania 15216

Date: May 1980

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 Department of the Army, 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 visual observations and review of available data. Detailed investigations and analyses involving topographic mapping, subsurface investigations, materials testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for such studies which should be performed by the owner.

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 the dam depends on numerous and constantly changing internal and external factors which are 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 time 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 investigations 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" (PMF) 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

SYNOPSIS OF ASSESSMENT AND RECOMMENDATIONS

NAME OF DAM:	Colonial No. 3
STATE LOCATION:	Pennsylvania
COUNTY LOCATION:	Fayette
STREAM:	Washwater Run, a tributary of Redstone Creek
DATE OF INSPECTION:	31 October 1979
COORDINATES:	Lat. 40° 00' 09" Long. 79° 45' 37"

ASSESSMENT

Based on a review of available design information, visual observations of conditions as they existed on the date of the field inspections, and hydrologic and stability calculations, the general condition of the Colonial Dam No. 3 is considered to be poor.

This assessment is based on:

1. Observation that the gravity dam structure has been partially breached at the right abutment.

2. Observations that physical deterioration of the dam and outlet works is significant.

3. Hydrologic/hydraulic calculations that indicate that the overflow crest has an "inadequate" discharge capacity.

The structure is classified as a "small" size, "significant" hazard dam. Corps of Engineers guidelines recommend a one hundred year flood to 1/2 the Probable Maximum Flood (PMF) for a "small" size, "significant" hazard dam. Colonial Dam No. 3 has a Spillway Design Flood of 1/2 the Probable Maximum Flood (PMF). Spillway capacity is "inadequate" because the non-overtopping flood discharge capacity, as estimated using the HEC-1 computer program, was found to be 0.09 PMF for an unbreached condition. The existing, breached condition, was not analyzed but is assessed to be hydrologically better than the unbreached condition.

RECOMMENDATIONS

1. Additional Investigations: Immediately retain a professional engineer knowledgeable in dam design and construction to:

a. Perform a detailed hydrologic/hydraulic analysis of the reservoir and dam and make recommendations on increasing the capacity of the system to make it adequate.

b. Investigate the operability of the outlet works and provide recommendations on repair requirements.

c. Provide recommendations on improving the physical condition of the deteriorated gravity dam and right abutment.

2. Emergency Operation and Warning Plan: Concurrent with the additional investigations recommended above, the owner should develop an Emergency Operation and Warning Plan including:

a. Guidelines for evaluating inflow during periods of heavy precipitation or runoff.

b. Procedures for around the clock surveillance during periods of heavy precipitation or runoff.

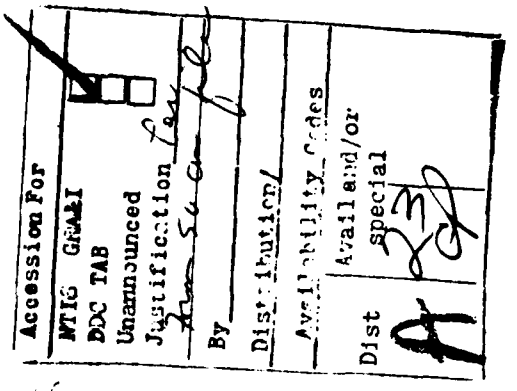
c. Procedures for drawdown of the reservoir under emergency conditions.

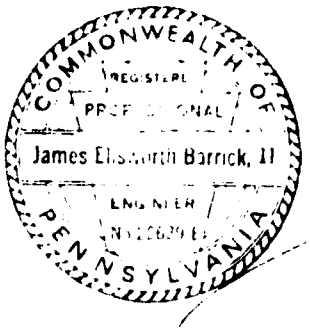
d. Procedures for notifying downstream residents and public officials, in case evacuation of downstream areas is necessary.

3. Inspection and Maintenance: The owner should immediately develop and implement formal inspection and maintenance procedures.

SYNOPSIS OF ASSESSMENT AND RECOMMENDATIONS (CONT'D)
Colonial Dam No. 3

4. Orderly Breaching: In lieu of performing the above recommendations, the owner should engage the services of a professional engineer, knowledgeable in dam design and performance, to prepare specifications for completely breaching the structure, to make it incapable of impounding water. The structure should then be breached under the direction of the professional engineer, in accordance with applicable state and local regulations.





James P. Hannan 23 May 1980
James P. Hannan Date
Project Engineer

James E. Barrick 23 May 1980
James E. Barrick, P.E. Date
PA Registration No. 022639-E

Approved by: 30 JUNE 1980
JAMES W. PECK Date
Colonel, Corps of Engineers
District Engineer

COLONIAL DAM No. 3

OVERVIEWS

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
COLONIAL DAM NO. 3
NATIONAL I.D. NO. PA 00209
PennDER No. 26-22

SECTION 1
PROJECT INFORMATION

1.1 GENERAL

a. Authority: The Phase I investigation was performed pursuant to authority granted by Public Law 92-367 (National Dam Inspection Act) to the Secretary of the Army through the Corps of Engineers, to conduct inspections of dams throughout the United States.

b. Purpose: The purpose of the investigation is to make a determination on whether or not the dam constitutes a hazard to human life or property.

1.2 DESCRIPTION OF PROJECT

a. Dam and Appurtenances:

(1) Concrete Gravity Dam: Colonial Dam No. 3 is a reinforced concrete, gravity type dam, 28.5 feet high and 161 feet long. The upstream face is vertical and the downstream face is 1H:2V. The dam crest is 5 feet wide at Elev. 924 and contains a 2.5 foot high by 2 foot wide concrete parapet which is discontinuous across the crest. The missing sections of parapet are 39.7 feet and 13.4 feet in length and allow normal and storm flows to discharge over the dam crest. Discharge is to the bedrock streambed below.

(2) Outlet Works: The outlet works consists of an 18 inch diameter cast iron pipe that is controlled on the upstream face by a 2.5 foot square, inoperative, sluice gate. The pipe branches downstream of the dam into a 12 inch pond drain and an 8 inch water supply pipeline which is now disconnected.

(3) Downstream Conditions: Washwater Run flows through a narrow, uninhabited, and steep-sided valley. Approximately 2,000 feet below the dam, the Run passes through a large culvert beneath a railroad embankment and discharges to Redstone Creek.

b. Location: Colonial Dam No. 3 is located in Jefferson Township, Fayette County, Pennsylvania, approximately one mile east of Grindstone and 0.8 miles north of Rowes Run. The dam is situated across Washwater Run, which is tributary to Redstone Creek, which is tributary to the Monongahela River at Brownsville, Pennsylvania.

c. Size Classification: The dam has a maximum storage capacity of 23 acre-feet and a toe to crest height of 28.5 feet. Based on Corps of Engineers guidelines, this dam is classified as a "small" size structure.

d. Hazard Classification: Colonial Dam No. 3 is a "significant" hazard dam. In the event of catastrophic failure of the dam, it is unlikely that the railroad embankment and the few dwellings along Redstone Creek below would suffer great damage or loss of life would result.

e. Ownership: Colonial Dam No. 3 is owned by the Redstone Water Company. Correspondence can be addressed to:

Redstone Water Company, Inc.
Box 548
California, Pennsylvania 15419
Attention: Mr. Edward Yablonski
412-938-9164

f. Purpose of Dam: Colonial Dam No. 3 was originally constructed to provide water for industrial use by the Pittsburgh Coal Company. It was subsequently sold to the Redstone Water Company to supply water for residential and domestic use. The reservoir is not now used for water supply purposes and its current use is unknown.

g. Design and Construction History: The dam was designed in 1907 by E. J.Taylor, Chief Engineer and Construction Supervisor for the Pittsburgh Coal Company. It was constructed by Maynard and Flynn, Contractors, of Pittsburgh, Pennsylvania in 1907.

h. Normal Operating Procedure: Colonial Dam No. 3 was designed to operate as an uncontrolled structure. Under normal operating conditions, the pool level is maintained at Elev. 924.1 by the crest of the concrete gravity dam.

1.3 PERTINENT DATA

a. Drainage Area: 1.5 sq. miles

b. Discharge at Dam Facility:

Maximum Known Flood at Dam Facility	600+ cfs* (flood of 4 June 1941)
Overflow Crest	280 cfs

c. Elevation (Feet Above MSL)*

Constructed Top of Dam (Parapet)	926.5*
Design Highwater	926.5*
Normal Pool (Unbreached)	924.1
Overflow Crest	924.1
Upstream Invert of Outlet Pipe	899.2*
Maximum Tailwater	Unknown
Downstream Toe	898.0

d. Reservoir Length:

Length of Maximum Pool	500 feet
Length of Normal Pool	450 feet

e. Total Storage:

Constructed Top of Dam	26 acre-feet
Design Highwater	26 acre-feet
Overflow Crest	23 acre-feet*
Normal Pool Level	23 acre-feet*

f. Reservoir Surface:

Constructed Top of Dam	2 acres
Design Highwater	2 acres
Overflow Crest	1.5 acres*
Normal Pool	1.5 acres*

g. Dam:

Type	Reinforced Concrete, Gravity
Length	161 feet*
Height	28.5 feet
Top Width	
At Crest	5 feet
At Top of Parapet	2 feet
Slopes	
Upstream	Vertical
Downstream	1H:2V
Cutoff Provisons	Grouted Foundation*

h. Outlet Works::

Type	18 inch diameter cast iron pipe*
Upstream Control	2.5 foot square sluice gate*
Outlet	Branch to 12 inch diameter pond drain and 8 inch diameter water supply pipe
Gate Valves	Both branches, downstream* (neither observed)

i. Overflow Crest:

Discharge Sections are broad crested weirs:

(1)	39.7 feet long at	Elev. 924.1
(2)	13.5 feet long at	Elev. 924.2
(3)	5.5 feet long at	Elev. 925.5

*Taken or derived from original design drawings or design information in PennDER files.

SECTION 2
ENGINEERING DATA

2.1 DESIGN

a. Data Available: The following written information and data may be obtained from the Pennsylvania Department of Environmental Resources, Harrisburg, Pennsylvania. The information was reviewed for this study.

(1) A design drawing, dated 8 August 1907, showing elevations and sections of the proposed dam and additional notes related to construction changes and subsequent dam modifications.

(2) Two "Reports Upon the H.C. Frick Coke Company's Dam" dated 25 June 1914 (draft) and 20 October 1914.

b. Design Features:

(1) Foundation: The dam was founded on sandstone bedrock, except near the crest, where shale was encountered. Bedrock was removed to an "average" depth of 2.5 feet and was reported to be quite dry and massive. Before construction of the dam, three irregularly spaced 3 inch diameter holes were drilled to a depth of 18 inches, tall pipes were inserted and the foundation was grouted with liquid grout under pipe head. The pipes were later encased in the concrete of the dam.

(2) Gravity Dam: The gravity dam was designed by E. J. Taylor of the Pittsburgh Coal Company in 1907. The dam had a two foot thick base slab 23 feet long and 39 feet wide (cross valley). The remainder of the dam, without base slab, was step-keyed into the abutment rock. The dam design called for a 5 foot wide crest, vertical upstream face, downstream face sloping at 1H:2V and a concrete parapet 18 inches high by two feet wide on the crest. The parapet had a 25 foot wide opening to allow normal and storm flow discharges. The concrete was to be reinforced with three inch square, 8 gage, wire mesh. The wire mesh sheets were to be placed adjacent to the dam surfaces and lapped one foot.

(3) Outlet Works: An 18 inch diameter cast iron outlet pipe was designed and was to be controlled on the upstream face by a 30 inch square sliding gate. Downstream, the pipe branched into eight inch and twelve inch lines, each with gate valve. The 12 inch line was a pond drain and the eight inch line was to supply water to the Colonial No. 3 mine.

2.2 CONSTRUCTION

a. Contractor: The dam was constructed for the Pittsburgh Coal Company by Maynard and Flynn, Contractors, of Pittsburgh, Pennsylvania in 1907. The work was performed under the direction of Ernest G. Taylor.

b. Field Changes: According to correspondence cited in Section 2.1a(2), that portion of the dam below the top of rock was made 3 feet wider than originally planned by stepping out 1 foot at the heel and 2 feet at the toe.

The dam was constructed to Elev. 925.5 instead Elev. 930 as originally intended.

2.3 MODIFICATION/REPAIR

a. 1908: One foot of concrete was added to the top of the parapet, bringing the dam top elevation to 926.5.

b. 1912: Following the storm of July 1912, when the dam was overtopped and the sides were washed out to bedrock, several corrective measures were undertaken.

(1) The reservoir was drained and all cracks on the upstream face were raked out and carefully pointed with a cement mortar and the entire upstream face was plastered with mortar.

(2) Extra masonry was placed on the dam's downstream face bringing the outline to the dimensions originally contemplated.

(3) Concrete blocks were placed along the downstream abutments to break the force of any water that might overflow the parapet.

(4) A portion of the dam was cut away and rebuilt about one foot deeper into the hillside.

(5) The length of the original overflow crest was increased from 25 feet to 39.7 feet by cutting out a portion of the concrete parapet.

(6) An additional spillway of 13.4 feet was cut out of the concrete parapet on the right side of the crest.

c. 1919: During the summer, holes were drilled into the dam and cement grout was forced into the concrete under pressure, stopping all leakage at the horizontal construction joints.

2.4 OPERATION

According to the Pennsylvania Department of Environmental Resources, the Redstone Water Company is responsible for operation of Colonial Dam No. 3.

The overflow crests are uncontrolled and performance and operation records are not maintained. The outlet works is not currently in use.

2.5 EVALUATION

a. Availability: Available design information and drawings were obtained from the Pennsylvania Department of Environmental Resources.

b. Adequacy: The available design information supplemented by field inspections and supporting engineering analyses in succeeding sections, is adequate for the purpose of this Phase I inspection report.

c. Validity: Based on the available data, there appears to be no reason to question the validity of the available design information and drawings.

SECTION 3
VISUAL INSPECTION

3.1 FINDINGS

a. General: The visual observations of Colonial Dam No. 3 and reservoir were performed on 31 October 1979, and consisted of:

(1) Visual observations of the concrete gravity dam and abutments.

(2) Visual observations of exposed sections of the outlet works.

(3) Visual observations of downstream conditions and evaluation of the downstream hazard potential.

(4) Visual observations of the reservoir shoreline and inlet stream channel.

(5) Transit stadia survey of relative elevations along the dam crest centerline.

The visual observations were performed when the reservoir was below normal pool operating level due to an erosional breach at the right abutment. Tailwater conditions were normal.

The field plan, elevation, dam crest profile, and section and the visual observations checklist containing the observations and comments of the field inspection team are contained in Appendix A. Specific observations are illustrated on photographs in Appendix C. Detailed findings of the visual inspection are presented in the following sections.

b. Concrete Gravity Dam:

(1) Configuration: The impounding structure is a concrete gravity dam with a vertical upstream face, steeply sloping downstream face, and an irregular crest profile developed to provide storm flow discharge capacity. A field plan, elevation, crest profile and section are included in Appendix A. At the time of the visual inspection, a breach was observed between the dam and the right abutment, that had lowered the reservoir pool approximately two feet below the normal

operating pool level. The inlet to the breach was clogged with debris that appeared to maintain the reservoir pool at a higher level than would have been possible with an unclogged breach. The breach was approximately eight feet wide at the top.

A grout pipe was observed near the downstream edge of the crest, approximately 50 feet right of the left abutment. Two steel Z's were attached, vertically, to the upstream face of the dam, about 70 feet right of the left abutment.

No evidence was found of reported concrete stilling blocks on the downstream abutments or the "extra masonry" splash pad placed on the downstream toe in 1912.

(2) Condition of Concrete: The impounding structure was observed to contain significant cracking of the parapet, significant spalling of concrete surfaces, and significant spalling and deterioration of construction joints. The downstream face of the dam had considerable moss, grass, and small trees growing.

No major structural cracks were observed.

(3) Vertical and Horizontal Alignment: No evidence was observed to indicate adverse vertical or horizontal movement of the dam. The crest was found by survey to be level and no skewing or offsets were observed. No evidence of tilting was observed.

(4) Seepage: Several seeps and considerable wetting were observed on the downstream face of the dam, particularly in the central portion of the structure. In general, the wet conditions were observed beginning at the approximate elevation of the water line on the upstream side and extended to the foundation. The seeping water appeared to be primarily associated with construction joint systems.

Three large seeps with flows estimated at five gallons per minute (gpm) each were observed about six feet below the dam crest near the toe of the dam on the left abutment.

(5) Foundation: The impounding structure is founded on bedrock which appeared to be a competent, fine grained sandstone. The portions of dam/foundation contact that were observed appeared tight and did not appear to be leaking.

(6) Abutments:

Left: The left abutment is a relatively steep, natural hillside which was heavily wooded upstream and downstream of the dam. No springs or seeps were observed in the abutment downstream of the dam, although a dense ground cover of leaves and brush may have obscured such observations.

A bedrock outcrop near the stream bed just below the toe of the dam was wet, but no flowing water was observed.

Right: The right abutment had generally the same conditions as the left abutment with respect to slope and cover. However, severe erosion of soil and rock has occurred in and just downstream of the breach described earlier. Normal inflow to the reservoir now passes into the breach, beneath the undercut right end of the dam, and is directed along the dam toe to the original creek channel below.

(7) Overflow Section: Under normal (unbreached) operating conditions, inflows to the reservoir are discharged over the dam crest, through the rectangular openings in the parapet. No other spillway facility was observed.

c. Outlet Works:

(1) Pond Drain: A 12 inch (nominal) diameter cast iron pipe pond drain outlets to the original Washwater Run channel just below the toe of the dam. The downstream end of the pipe was broken, badly deteriorated and dirt clogged. The concrete encasement around the pipe extending beyond the dam structure was also badly deteriorated and no flow control devices were observed. No discharge was observed.

The inlet end of the pipe was not observed due to the reservoir pool level. However, the two steel sluice gate slides on the upstream face of the dam were badly rusted.

(2) Water Supply Pipe: An eight inch (nominal) diameter cast iron water supply pipe was observed to pass through the dam immediately above the pond drain pipe. The eight inch pipe extended downstream several feet past the pond drain discharge point, but terminated at an open end condition. No flow controls were observed downstream of the dam and no water was discharging from the end of the pipe.

d. Instrumentation: No instrumentation was observed during the visual inspection.

e. Reservoir:

(1) Slopes: The reservoir slopes were observed to be generally steep and densely wooded. No recent shoreline slope instability was noted.

(2) Sedimentation: The upper end of the reservoir was silted in, but was covered with dense brush.

Water depth measurements along the upstream face of the dam indicated a sediment level four feet below the water surface.

(3) Watershed: Conditions in the watershed did not appear to be significantly different from those indicated on the U.S.G.S. 7-1/2 minute quadrangle. The watershed is mostly farm and woodland and no mining or major construction operations were observed.

f. Downstream Channel:

(1) Flow Conditions: The downstream channel in the first 2,000 feet below the dam, lies in a narrow, steep-sided valley, that is heavily wooded. The channel has a very rough bedrock bottom, undergoes several turns, and is generally clogged with down timber and debris.

Several hundred feet downstream of the dam there is a twelve to fifteen foot high waterfall in Washwater Run. The waterfall appeared to be the result of erosion rather than differential bedrock displacement.

(2) Railroad Embankment: A railroad embankment crosses the mouth of Washwater Run valley at the confluence with Redstone Creek. A concrete and masonry culvert transports the Run beneath the embankment. The culvert's controlling cross section is half an ellipse with a minor radius of five feet horizontally and a radius of seven feet vertically. The embankment is about 26 feet high, has a crest width of more than 30 feet, and contains a single railroad track and a gravel surfaced access road.

(3) Flood Plain Development: The first inhabited dwelling below Colonial Dam No. 3 lies on the floodplain of Redstone Creek at Rowes Run, about 2,500 feet below the dam. At least four inhabited dwellings lie on the flood plain in the first 6,000 feet below the dam. All the dwellings appeared to be more than four feet above the base of the Redstone Creek channel.

3.2 EVALUATION

a. Impounding Structure: The concrete gravity dam is considered to be in poor condition. This is based on the observed breach at the right abutment and the general condition of the structural concrete, particularly spalling at construction joints and deterioration of the parapet and crest. Significant seepage on the downstream face indicates water passages through the dam. Vertical and horizontal alignments appeared satisfactory and no tilting or skewing of the dam was noted. No major structural cracks were observed.

b. Right Abutment: The right abutment is considered to be in poor conditon because of significant erosion due to water flowing in the breach. The base of the breach channel is on bedrock, but the sides consisted of barren, steep soil slopes. Continued, detrimental erosion can be anticipated.

c. Outlet Works: The outlet works are considered to be in poor condition. This is based on observed deterioration of pipes and sluice gate slides. Sluice gate operating controls or other valves were not observed.

d. Sedimentation: The reservoir was observed to be significantly silted; only four feet of standing water was observed at the dam.

e. Downstream Conditions: In the judgement of the evaluating engineer, the observed downstream conditions indicate that the hazard classification for Colonial Dam No. 3 is "significant". This is based on field observations of the downstream railroad embankment's height, crest width, and culvert capacity, and Redstone Creek floodplain development conditions. It was felt that even a catastropic failure of Colonial Dam No. 3 would not cause a catastropic failure of the railroad embankment. Rather, the railroad embankment culvert would throttle and control the discharge to Redstone Creek.

SECTION 4
OPERATIONAL FEATURES

4.1 PROCEDURE

Reservoir pool level is maintained by the uncontrolled concrete overflow crest of the gravity dam. Normal operating procedure does not require a dam tender.

When used for water supply purposes, the outlet works is normally open and discharge is to the 8 inch diameter cast iron water supply pipe. A gate valve (not observed) controls flow from the 12 inch diameter pond drain.

The water supply system is not now in use and flow controls are closed.

4.2 MAINTENANCE OF DAM AND OPERATING FACILITIES

Colonial Dam No. 3 and appurtenances are not maintained.

4.3 INSPECTION OF DAM

The Redstone Water Company is required by the State of Pennsylvania to inspect the dam annually and make needed repairs.

4.4 WARNING SYSTEM

There are no warning systems or formal emergency procedures to alert or evacuate downstream residents upon threat of a dam failure.

4.5 EVAULATION

There are no written operation, maintenance or inspection procedures, nor is there a warning system or formal emergency procedure for this dam. These procedures should be developed in the form of checklists and step by step instructions, and should be implemented as necessary.

SECTION 5
HYDROLOGY AND HYDRAULICS

5.1 EVALUATION OF FEATURES

a. Design Data: Colonial Dam No. 3 has a watershed of 960 acres which is vegetated primarily by woodland and farmland. The watershed is about two miles long, one mile wide and has a maximum elevation is 1,240 feet above Mean Sea Level (MSL). At normal pool, the dam impounds a reservoir with a surface area of 1.5 acres and a storage volume of 23 acre-feet. Normal pool elevation was maintained at Elev. 924.1 by the overflow crest, prior to partial breaching.

According to Penn DER files, the overflow crest capacity was made sufficient to accommodate 506 cubic feet per second per square mile which was considered adequate for this structure and watershed. The Colonial Dam No. 3 capacity for the observed cross section and existing freeboard condition was computed to be 280 cfs. No additional hydrologic calculations were found relating reservoir/spillway performance to the Probable Maximum Flood or fractions thereof.

b. Experience Data: Continuous records of reservoir level or rainfall amounts are not kept. Records of the structure being overtopped include a flow depth of 0.5 foot in July 1912 and a depth of 1.1 feet during the storm of 4 June 1941.

c. Visual Observations: On the date of the field reconnaissance, severe deterioration of the concrete overflow sections was observed. An 8 foot wide erosion breach was observed in the right abutment. In order to perform the HEC-1 analysis, it was assumed that this condition was repaired and the structure performed as designed. This assumption was made because the repaired condition is considered to be hydrologically more unsafe than the existing breached condition.

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 overflow crest. The Corps of Engineers guidelines recommend the 100 year flood to 1/2 the PMF for "small" size, "significant" hazard dams. Based on the observed downstream conditions, Colonial Dam No. 3 has a Spillway Design Flood (SDF) of one half PMF.

Hydrometeorological Report No. 33 indicates the adjusted 24 hour Probable Maximum Precipitation (PMP) for the subject site is 19.4 inches. No calculations are available to indicate whether the reservoir and overflow crest are sized to pass a flood corresponding to 9.7 inches of rainfall in 24 hours (1/2 PMP). Consequently, an evaluation of the reservoir/overflow crest system was performed to determine whether the overflow crest capacity is adequate under current Corps of Engineers guidelines.

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

The peak inflow to Colonial Dam No. 3 for the SDF was determined by HEC-1 to be 1637 cfs.

e. Adequacy: For the design condition (without breach), the capacity of the combined reservoir and overflow crest system was determined to be 0.09 PMF. An initial pool elevation of 924.1 was assumed prior to commencement of the storm. According to Corp of Engineer's guidelines, Colonial Dam No. 3 overflow crest capacity is "inadequate."

At 0.50 PMF, the Colonial Dam No. 3 parapet is overtopped by 1.18 feet of water for a duration of 10 hours (unbreached condition).

SECTION 6
STRUCTURAL STABILITY

6.1 AVAILABLE INFORMATION

a. Visual Observations: On the date of the field reconnaissance, four observations were made that are significant to an evaluation of the structural stability of Colonial Dam No. 3. These observations are:

(1) Extensive erosion of the right abutment (breach) that has reduced the effective foundation contact area of the dam.

(2) Extensive leakage on the downstream face of the dam, particularly in the area of construction joints, that indicates the existence of openings through the dam.

(3) A considerable accumulation of silt in the reservoir.

(4) Lack of a concrete "batter" at the toe of the dam that was reported to have been placed in 1912. The observed downstream dam slope was more or less constant from crest to toe at 1H:2V.

b. Design and Construction Data: Available design and construction data pertinent to the structural stability of the dam includes:

(1) The drawing referenced in Section 2.1a(1) above and reproduced as Plate III in Appendix E.

(2) Reports in the correspondence that the dam foundation was cement grouted under low head during construction and that the dam itself was grouted in 1919 to seal leaks.

c. Performance Data: According to information in the PennDER files, Colonial Dam No. 3 has been overtopped without failure, twice in its lifetime - by 0.5 foot in July 1912 and by 1.1 feet on 4 June 1941.

d. Previous Stability Analysis: A comprehensive stability analysis of the dam was performed by engineers of the Department of Forest and Waters in 1914. The analysis evaluated both overturning and sliding stability and was presented in the reports referenced in Section 2.1a(2) above. Results of the analysis and two pages of supporting calculations, also obtained from PennDER files, are contained in Appendix G.

6.2 STABILITY ANALYSIS

a. General: An analysis of sliding and overturning stability was performed to evaluate the dam for existing conditions.

b. Assumptions:

(1) The right abutment breach length is not affected by uplift pressures and offers no sliding or passive resistance.

(2) The unit weight of wire mesh reinforced concrete is 145 pcf.

(3) Sediment behind the dam has a total unit weight of 80 pcf, an effective angle of internal friction of 3°, and no cohesive strength.

(4) The foundation bedrock has a total unit weight of 140 pcf, an effective angle of internal friction of 45°, and no cohesive strength.

(5) The coefficient of friction between mass concrete and clean bedrock is 0.70 (Ref. NAVFAC-DM7, Table 10-1).

(6) Weight and drag forces caused by the flow of water over the dam are negligible.

(7) Foundation uplift pressure varies linearly from a maximum of 100 percent hydrostatic at the upstream edge of the dam to zero at the downstream edge.

(8) Rankine empirical formulas are applicable for determining passive and active lateral earth pressures for the downstream rock key and reservoir sediment, respectively.

(9) The dam is keyed 2.5 feet into rock.

(10) The breach will be debris clogged during large meteorological events, such that unbreached reservoir pool levels will exist.

c. Sliding Stability: Sliding stability of the existing dam configuration was analyzed for static conditions to estimate the amount of cohesion required between the dam and foundation to give a safety factor (SF) against sliding of 3. The dam was analyzed as a three dimensional, rigid body to more accurately characterize the relationship between driving and resisting forces. The pool level associated with the SDF (Elev. 927.7) was employed in the analysis. To achieve a SF of 3, it was determined that a cohesion of 20 psi, acting over the unbreached portion of the foundation, is required. The calculations are contained in Appendix G.

d. Overturning Stability: Overturning stability of the existing dam was analyzed for static and seismic conditions using a two dimensional rigid body model (one foot wide section).

For static conditions and the SDF pool level (Elev. 927.7), the safety factor against overturning was found to be 1.11 and the resultant force was located 2.2 feet upstream of the downstream toe of the dam. Since the base third point is 6.7 feet upstream of the downstream toe, the toe stress condition was evaluated and found to be 4.3 tons per square feet (TSF).

Corresponding conditions were analyzed for a seismic load equivalent to a static horizontal load of 0.025g (Zone I condition). The safety factor against overturning was determined to be 1.09 and the resultant force was located 1.8 feet above the downstream toe. Accordingly, the toe stress was analyzed to be 5.4 TSF.

6.3 EVALUATION OF STRUCTURAL STABILITY

a. Sliding Stability: Colonial Dam No.3 is considered to have an adequate margin of safety against sliding. This is based on the analysis indicating that a dam/foundation cohesion of 20 psi is necessary to achieve a sliding factor of safety of three. A dam/foundation cohesion of this magnitude is considered to be reasonable based on visual observations and general experience.

a. Overturning Stability: Colonial Dam No. 3 is considered to have an adequate margin of safety against overturning for both static and seismic conditions. Although the resultant force is not located within the middle third of the dam for the analyzed conditions, toe pressures were calculated to be considerably less than the allowable maximums for the dam's concrete and foundation rock.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS

7.1 ASSESSMENT

a. Evaluation:

(1) Gravity Dam: The concrete gravity dam is considered to be in poor condition. This is based on:

i. The observed breach at the right end of the dam that has resulted in considerable erosion of the dam and abutment.

ii. The observed condition of concrete surfaces, that showed significant spalling, deterioration, seepage and leakage.

iii. The observed deteriorated condition of the outlet works pipes and flow controls.

iv. The "inadequate" capacity rating of the overflow crest using the HEC-1 computer program.

(2) Hazard Classification and Spillway Design Flood: Visual observations of flood plain conditions below Colonial Dam No. 3 indicate the structure has a "significant" hazard classification that requires a SDF of 0.5 PMF.

b. Adequacy of Information: The information available on design, construction, operation and performance, in combination with visual observations and hydrology, hydraulic and stability calculations were sufficient to evaluate the dam in accordance with the Phase I investigation guidelines.

c. Urgency: The recommendations presented in Section 7.2a and 7.2c should be implemented immediately

7.2 RECOMMENDATIONS

a. Additional Investigations: Immediately retain a professional engineer knowledgeable in dam design and construction to:

(1) Perform a detailed hydrologic/hydraulic analysis of the reservoir and dam and make recommendations on increasing the capacity of the system to make it adequate.

(2) Investigate the operability of the outlet works and provide recommendations on repair requirements.

(3) Provide recommendations on improving the physical condition of the deteriorated gravity dam and right abutment.

b. Emergency Operation and Warning Plan: Concurrent with the additional investigations recommended above, the owner should develop an Emergency Operation and Warning Plan including:

(1) Guidelines for evaluating inflow during periods of heavy precipitation or runoff.

(2) Procedures for around the clock surveillance during periods of heavy precipitation or runoff.

(3) Procedures for drawdown of the reservoir under emergency conditions.

(4) Procedures for notifying downstream residents and public officials, in case evacuation of downstream areas is necessary.

c. Inspection and Maintenance: The owner should develop and implement formal inspection and maintenance procedures.

d. Orderly Breaching: In lieu of performing the above recommendations, the owner should engage the services of a professional engineer, knowledgeable in dam design and performance, to prepare specifications for completely breaching the structure, to make it incapable of impounding water. The structure should then be breached under the direction of the professional engineer, in accordance with applicable state and local regulations.

APPENDIX A

VISUAL INSPECTION CHECKLIST

VISUAL OBSERVATIONS CHECKLIST II
(MASONRY IMPOUNDING STRUCTURE)

Name Dam Colonial No. 3 County Fayette State Pennsylvania National ID # PA 00209

Type of Dam Concrete Gravity Hazard Category Significant

Date (s) Inspection 31 October 1979 Weather Clear, Warm Temperature 68°

Pool Elevation at Time of Inspection 922 ± (MSL) Tailwater at Time of Inspection 898 ± (MSL)

Inspection Personnel:

J. E. Barrick, P.E.	Ackenheil & Associates, Hydrologist and Project Manager.
J. P. Hannan,	Ackenheil & Associates, Geotechnical Engineer
S. G. Mazzella,	Ackenheil & Associates, Civil Engineer
E. Yablonski,	Redstone Water Company, Owner's Representative

Recorder J. E. Barrick

Geo Project G79153-H
PennDER I.D. No. 26-22

CONCRETE/MASONARY DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
GENERAL DESCRIPTION	Colonial Dam No. 3 is a concrete gravity structure which appears to be keyed into bedrock. The crest is five feet wide and contains three - two foot wide crest blocks that are 2.5 feet high. The upstream face is vertical and the downstream face is approximately 1H:2V. The dam is an overflow structure and has no detached spillway. However, a breach has developed at the right abutment and currently serves as the dam's principal spillway.	
SURFACE CRACKS CONCRETE SURFACES	Crest blocks (parapet) are badly cracked. Downstream face is badly cracked vertically and horizontally. Downstream face is badly spalled with grass and small trees growing on it.	
STRUCTURAL CRACKING	No significant structural cracks were observed.	
VERTICAL AND HORIZONTAL ALIGNMENT	There does not appear to have been any vertical or horizontal displacement of the structure. Crest is straight and appears level. No evidence of settlement is apparent.	
MONOLITH JOINTS	Spalled cracks observed at several locations.	
CONSTRUCTION JOINTS	Downstream face construction joints are noticeable due to considerable spalling.	
STAFF GAGE AND RECORDER	None observed.	

CONCRETE/MASONARY DAM
(INCLUDING OVERFLOW AND NON-OVERFLOW SECTIONS)

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	A seep or wet spot approximately 20 feet up the dam face on right side near the end of the right crest block. An actively flowing seep on right face of dam, just left of the end of right crest block and 7 feet below crest - estimated flow 1 gallon per minute. Significant flow around right abutment beneath the concrete structure in vicinity of breach. This flow is directed along the toe of the dam to the channel below. Numerous seeps in the central portion of the downstream face, the highest of which is 2 feet below crest; other seeps emanating from spalled and cracked sections four and more feet below crest. Three seeps, each discharging approximately 5 gallons per minute, are located six feet below the crest and near the left abutment.	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Structure to abutment seals appear to be generally adequate with exception of breach at right end of structure and three seeps on the left abutment.	
DRAINS	None observed.	
WATER PASSAGES	Leaks, wet areas observed at many construction joints and cracks.	
FOUNDATION	Appears to be adequate. Lower part of structure observed to be founded on competent sandstone.	

CONCRETE/MASONRY DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed.	
SLOUGHING OR EROSION OF NON-OVERFLOW SECTION SLOPES	None observed.	
RIPRAP FAILURES	No riprap observed.	

UNGATED OVERFLOW SECTION
(DAM CREST)

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Badly deteriorated concrete with construction joint cracks.	
APPROACH CHANNEL	Reservoir - unblocked access to weir crest.	
DISCHARGE CHANNEL	Consists of natural rock with steep, heavily wooded side slopes.	
BRIDGE AND PIERS	None observed.	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Concrete encasement for outlet pipes below toe of dam is badly deteriorated.	
INTAKE STRUCTURE	Not observed due to pool level. Above water level, sluice gate slides are badly rusted and do not appear capable of supporting load. Sluice gate width is 30 inches.	
OUTLET STRUCTURE	Outlet pipe 12 inch C.I. and abandoned 8 inch C.I. water supply pipe lies immediately above cast iron outlet pipe. Outlet pipe is broken near end and partially clogged with mud.	
OUTLET CHANNEL	Discharge directly to Washwater Run below toe of dam.	
EMERGENCY GATE	See "Intake Structure" above.	

INSTRUMENTATION

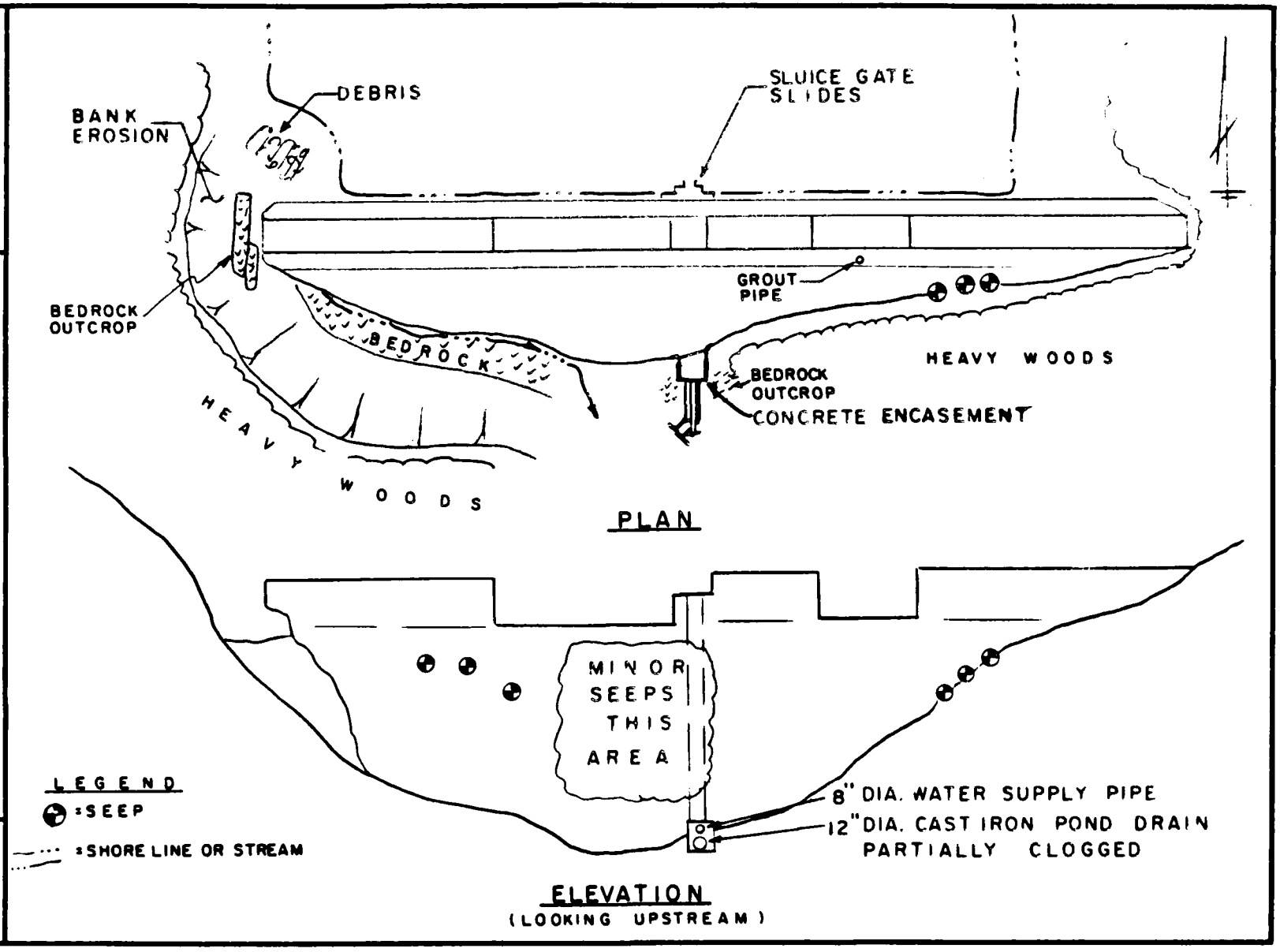
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None observed.	
OBSERVATION WELLS	None observed.	
WEIRS	None observed.	
PIEZOMETERS	None observed.	
OTHER	None observed.	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Generally steep, heavily wooded. No observed recent slope instability around shoreline except at breach area, where erosion of slope is significant.	
SEDIMENTATION	Entire upper end of pond sedimented and covered with vegetation. Sedimentation measured to be four feet below water level along upstream face of dam.	
WATERSHED	Conditions appear to be similar to those indicated on the most recent U.S.G.S. 7-1/2 minute topographic map. No new mining operations or major construction sites were observed. Watershed is mostly farm and woodland.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Width of downstream channel varies from 50 to 100 feet. Channel banks densely wooded. Considerable brush and downtimber. High "n" conditions. Extends approximately 2000 feet where it flows into Redstone Creek.	
SLOPES	Slopes very steep, heavily wooded. Considerable rock outcrop in valley.	
RAILROAD CULVERT	Immediately upstream of confluence with Redstone Creek, Wahwater Run channel flows through a culvert under a railroad embankment. The entrance is a horseshoe type culvert with flared 45° wingwalls. Culvert entrance is 12 feet high, base width 10.5 feet. Embankment above is 3.5H:2.5V and is 26 feet on the slope to the crest. (Total height above stream bed is 27 feet). Crest width greater than 30 feet and contains a single railroad track and gravel surfaced road.	
APPROXIMATE NO. OF HOMES AND POPULATION	One uninhabited dwelling present in flood plain immediately downstream of culvert outlet. Below this is a beverage distribution building with a residence on the 2nd floor. Across the road from this structure is an uninhabited building. Next nearest inhabited dwelling on floodplain is at Grindstone, 0.9 miles below the railroad culvert (1.7 miles below dam).	

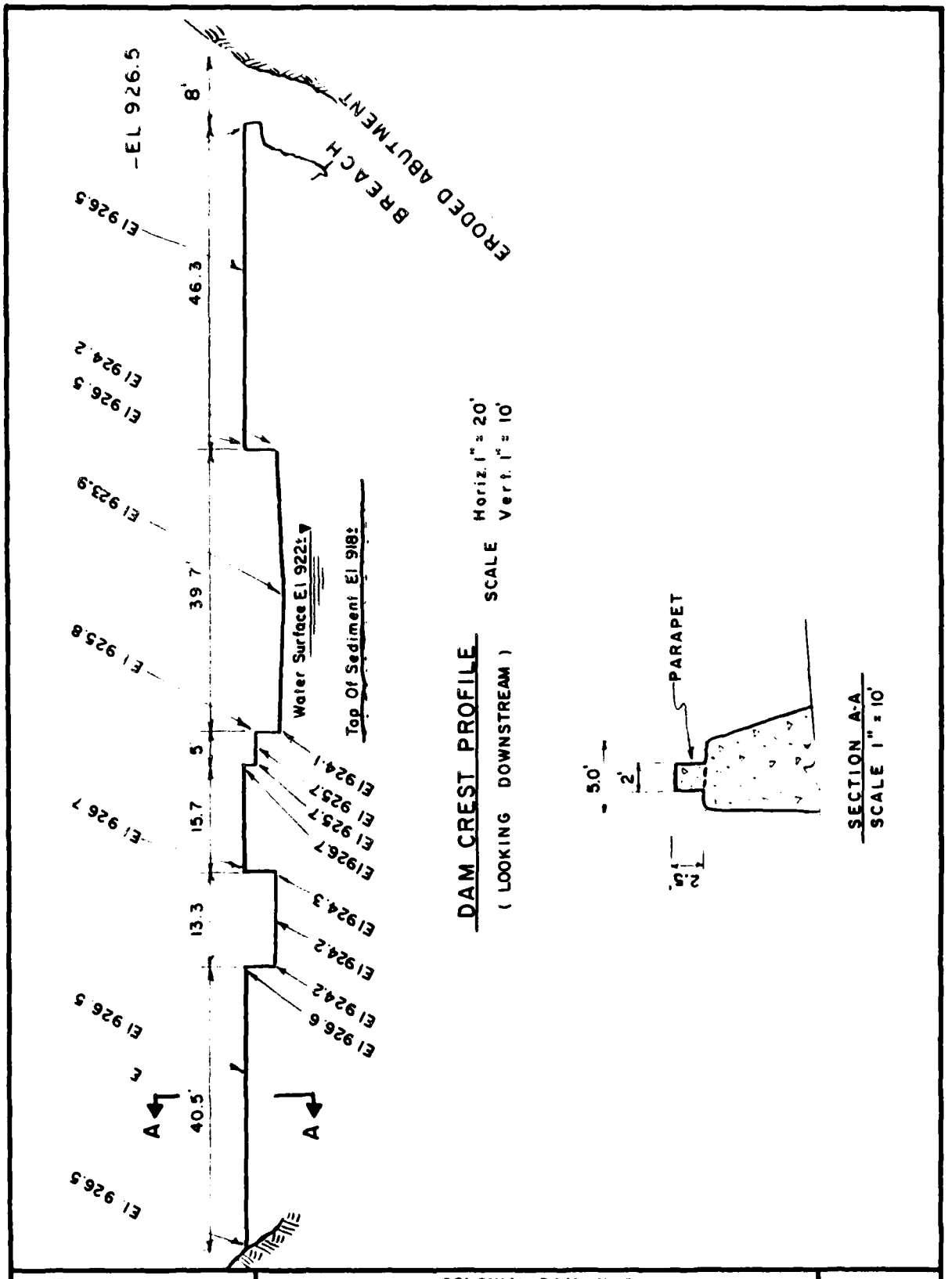


DATE: MAY 1980
SCALE: NONE
DR: PT CK: J.E.B.

A. C. ACKENHEIL & ASSOCIATES, INC.
CONSULTING ENGINEERS
PITTSBURGH, PA., CHARLESTON, W. VA. & BALTIMORE, MD.

COLONIAL DAM No.3
NATIONAL DAM INSPECTION PROGRAM

FIELD PLAN AND ELEVATION



DATE: MAY 1980	COLONIAL DAM No 3		DAM CREST PROFILE AND SECTION
SCALE: AS SHOWN	NATIONAL DAM INSPECTION PROGRAM		
DR: J F	CK: JEB	A. C. ACKENHEIL & ASSOCIATES, INC. CONSULTING ENGINEERS PITTSBURGH, PA., CHARLESTON, W. VA. & BALTIMORE, MD.	

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APPENDIX B

ENGINEERING DATA CHECKLIST

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM Colonial No. 3
I.D. No. PA 00209

ITEM	REMARKS
*Design Drawings	**Drawing E 10281, "Section on Line "C", Washwater Run, for Proposed Dam", dated 8 August 1907. Unnamed and undated drawing showing details of winch operated sluice gate control.
*As-Built Drawings	See Design Drawings above for added notes and information related to construction changes and subsequent modifications. **"Plan Showing Topography, Washwater Run Below the Dam, Colonial No. 3 Mine, Jefferson Township, Fayette County, Pennsylvania," dated 22 August 1912, numbered 26-22=2.
Regional Vicinity Map	U.S.G.S. 7-1/2 Minute Fayette City, Pennsylvania Quadrangle. See Appendix E.

ITEM	REMARKS
*Construction History	Plans were prepared by E. J. Taylor, Chief Engineer and Construction Supervisor, Pittsburgh Coal Company, 1907. Built in 1907 by Maynard and Flynn, Contractors of Pittsburgh, Pennsylvania.
*Typical Sections of Dam	See Design Drawings above.
*Outlets - Plans Details Constraints	See Design Drawings above.
Outlet Discharge Ratings	See Design Reports below.
Rainfall/Reservoir Records	See Design Reports below.
*Design Reports	See "Report Upon the H.C. Frick Coke Company's Dam" dated Harrisburg, 20 October 1914. Also, draft report, dated 25 June 1914.
Geology Report	None available.
Hydrology and Hydraulics	See Design Reports above.

ITEM	REMARKS
*Design Computations Dam Stability Seepage Studies	See Design Reports above. Also, pencil drawing titled "H. C. Frick Coke Company, Dam on Washwater Run, for Colonial #3 Plant" undated, showing dam cross-section.
Materials Investigations Boring Records Laboratory Field	None available.
Post-Construction Surveys of Dam	See As-Built Drawings above.
Borrow Sources	Not applicable.
*Modifications	See As-Built Drawings above. In 1908 the parapet was increased 1 foot in height from elevation 925.5 to 926.5. Following the storm of July 1912 when the dam was overtopped and the sides were washed out down to bedrock, several corrective measures were undertaken during October and November of 1912:

ITEM	REMARKS
*Modifications (continued)	(1) Reservoir was drained and all cracks which showed on the upstream face were raked out and carefully pointed with a cement mortar and the entire upstream face was plastered with mortar.
	(2) Extra masonry was placed on the dam's downstream face carrying out the outline to the dimensions originally contemplated.
	(3) Concrete blocks were placed along the side hill downstream to break the force of any water that might overflow the parapet.
	(4) A portion of the dam was cut away and rebuilt, being carried about 1 foot deeper into the hillside than before.
	(5) The length of the original spillway near the center of the dam was increased from 25 feet to 39.7 feet by cutting out a portion of the concrete.
	(6) An additional spillway of 13.4 feet in length was cut out of the concrete on the right side.

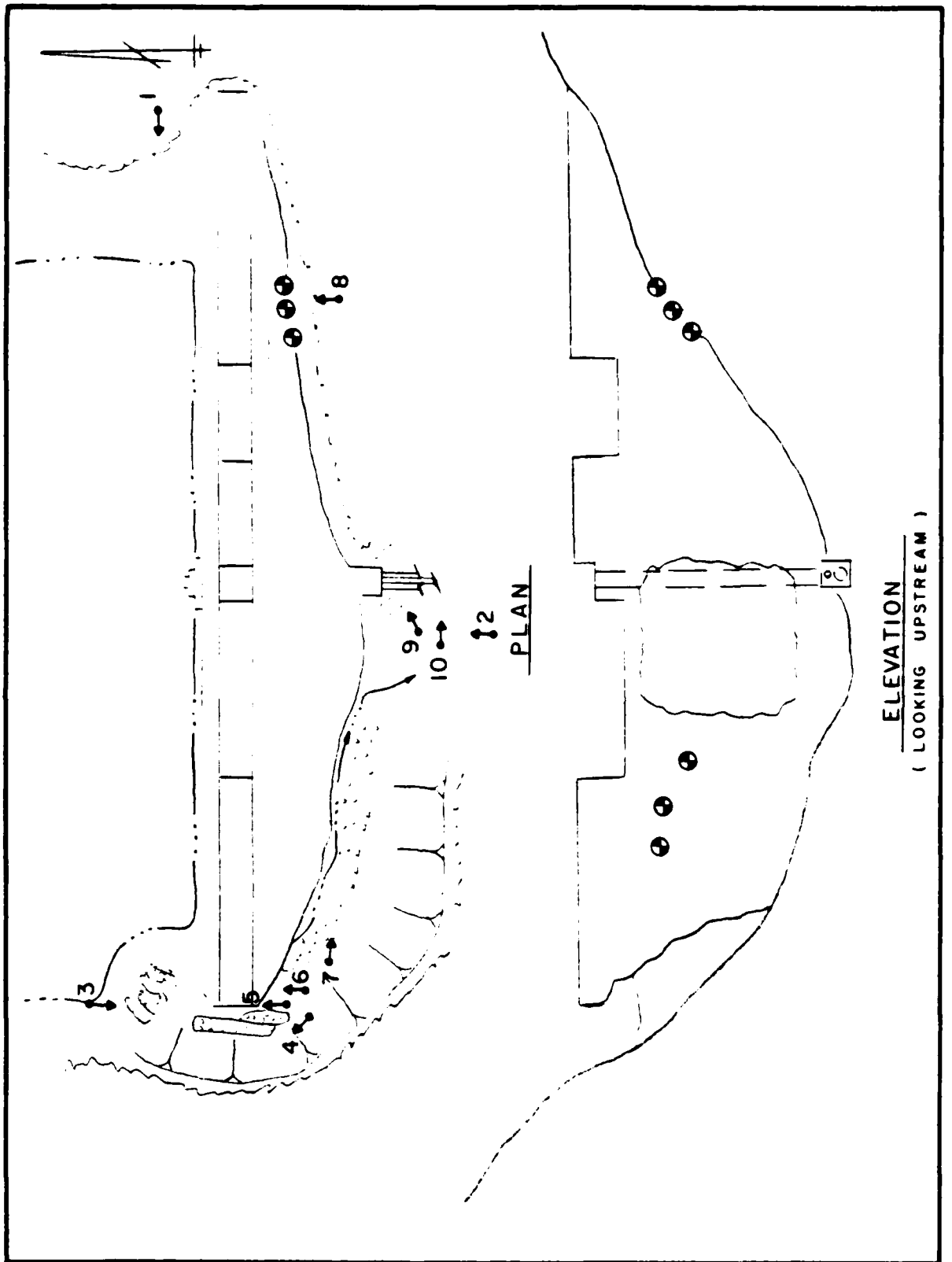
ITEM	REMARKS
*Modifications (continued)	During the summer of 1919, holes were drilled into the concrete and cement grout was forced into the concrete under pressure which stopped all leakage at the horizontal construction joints.
*High Pool Records	Miscellaneous correspondence indicates that the storm of July 1912 overtopped the parapet of the dam by 6 inches. The flood of 4 June 1941 overtopped the parapet by 1.1 feet.
*Post-Construction Engineering Studies and Reports	See As-Built Drawings above. Twelve inspection reports by Water and Power Resources Board personnel dated 15 June 1914 through 16 August 1961. One inspection report by owner, dated 12 June 1924.
Prior Accidents or Failure of Dam Description Reports	None reported.
Maintenance Operation Records	None available.
*Spillway - Plan Section Details	See Design Drawing above.
Specifications	None available.

* Information and data may be obtained from the Pennsylvania Department of Environmental Resources, Harrisburg, Pennsylvania.

**Included as plates in Appendix E.

APPENDIX C

PHOTOGRAPHS



DATE: MAY 1980		COLONIAL DAM No.3 NATIONAL DAM INSPECTION PROGRAM	PHOTO KEY MAP
SCALE: NONE			
DR: PT	CK: JEB	A. C. ACKENHEIL & ASSOCIATES, INC. CONSULTING ENGINEERS PITTSBURGH, PA., CHARLESTON, W. VA. & BALTIMORE, MD.	

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COLONIAL DAM No 3

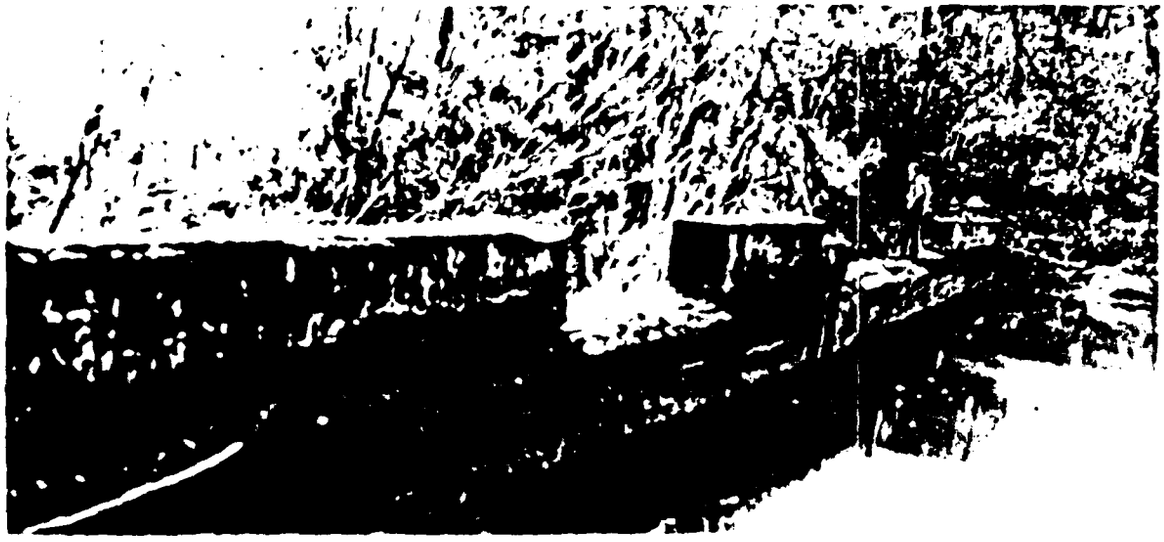

PHOTO UPSTREAM FACE

PHOTO 2 DOWNSTREAM FACE

PHOTO 3 RIGHT ABUTMENT BREACH

PHOTO 4. RIGHT ABUTMENT BREACH

COLONIAL DAM No 3

PHOTO 5 BREACH FLOW

PHOTO 6 BREACH

PHOTO 7 BREACH DISCHARGE CHANNEL

PHOTO 8. SEEPAGE

COLONIAL DAM No 3

PHOTO 9. OUTLET WORKS PIPES

PHOTO 10. POND DRAIN OUTLET

DETAILED PHOTO DESCRIPTIONS

Photo 1 Upstream Face of dam from left abutment, showing parapet openings and right abutment. Note debris in vicinity of the breach.

Photo 2 Downstream Face showing deteriorated concrete surfaces and vegetal growth on dam.

Photo 3 Right Abutment Breach looking downstream. Showing dam crest overhang.

Photo 4 Right Abutment Breach looking upstream. Note erosion of abutment.

Photo 5 Breach Flow as seen from below dam. Water is discharging from beneath the concrete dam.

Photo 6 Breach looking upstream showing overhanging condition of dam crest.

Photo 7 Breach Discharge Channel looking downstream from breach. Dam toe is at left of photo.

Photo 8 Seepage through dam on left abutment.

Photo 9 Outlet Works Pipes at toe of dam. Water supply pipe above and pond drain pipe below.

Photo 10 Pond Drain Outlet showing broken and deteriorated conditions.

APPENDIX D

HYDROLOGY AND HYDRAULICS ANALYSES

APPENDIX D
HYDROLOGY AND HYDRAULICS

Methodology: The dam overtopping analysis was accomplished using the systemized computer program HEC-1 (Dam Safety Version), July, 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 Report No. 33" prepared by the U.S. Weather Bureau.

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 analyses.

Parameter	Definition	Where Obtained
Ct	Coefficient representing variations of watershed	From Corps of Engineers*
L	Length of main stream channel	From U.S.G.S. 7.5 minute topographic map
Lca	Length on main stream to centroid of watershed	From U.S.G.S. 7.5 minute topographic map

Cp	Peaking coefficient	From Corps of Engineers*
A	Watershed size	From U.S.G.S. 7.5 minute topographic map

3. Routing: Reservoir routing is accomplished by using Modified Puls 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.

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

HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: Mostly woodland and pasture

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 924.1 (23 acre-feet).

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 925.7 (26 acre-feet).

ELEVATION MAXIMUM DESIGN POOL: 925.7

ELEVATION TOP DAM: 925.7 (minimum) 926.5 (average)

OVERFLOW SECTIONS

a. Elevation 924.1 (right) 924.2 (left)
b. Type Free overfall
c. Width 5 feet
d. Length 39.7 feet (right) 13.3 feet (left)
e. Location Spillover right and left of center
f. Number and Type of Gates None

OUTLET WORKS

a. Type 12 inch cast iron pipe
b. Location left of center
c. Entrance Inverts + 899.25
d. Exit Inverts + 899
e. Emergency Drawdown Facilities Sluice gate (inoperative)

HYDROMETEOROLOGICAL GAGES

a. Type None
b. Location N/A
c. Records None

MAXIMUM REPORTED NON-DAMAGING DISCHARGE Parapet overtopped by 1.1 feet during storm of 4 June 1941 also by 0.5 foot in July 1912.

HEC-1 DAM SAFETY VERSION
HYDROLOGY AND HYDRAULIC ANALYSIS
DATA BASE

NAME OF DAM: Colonial Dam No. 3	NDI ID NO. PA 209
Probable Maximum Precipitation (PMP)	24.2*
Drainage Area	1.5 sq. mi.
Reduction of PMP Rainfall for Data Fit Reduce by 20%, therefore PMP rainfall =	=19.4 in.
Adjustments of PMF for Drainage Area (Zone 7)	
6 hrs.	102%
12 hrs.	120%
24 hrs.	130%
Snyder Unit Hydrograph Parameters	
Zone	29**
C_p	0.5
C_t	1.6
L	2.0 mile
L_{ca}	1.1 mile
$t_p = C_t (L \cdot L_{ca})^{0.3}$ =	2.0 hours
Loss Rates	
Initial Loss	1.0 inch
Constant Loss Rate	0.05 inch/hour
Base Flow Generation Parameters	
Flow at Start of Storm	1.5 cfs x 1.5 sq.mi.=2.25 cfs
Base Flow Cutoff	0.5 peak
Recession Ratio	2.0
Overflow Section Data	
Crest Length	13.3 and 39.7 feet
Freeboard	1.6 feet
Discharge Coefficient	2.3-3.08
Exponent	1.5
Discharge Capacity	316.4 cfs

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* Hydrometerological Report 33
** Hydrological zone defined by Corps of Engineers, Baltimore District, for determining Snyder's Coefficients (C_p and C_t).

Sheet _____ of _____

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(412) 531-7111

Job Colonial Dam #3 Job No. 79153 H

Subject Data Input

Made By JDH Date 4/28/80 Checked EHB Date 4/28/80

Loss Rate and Base Flow Parameters

As Recommended by Corps of Engineers, Baltimore District

STRTL = 1 inch
CNSTL = 0.05 inches/hour
STRTQ = 1.5 cfs/mi²
QRCSN = 0.05 (5% of Peak Flow)
RTIOR = 2.0

Elevation - Area - Capacity - Relationships

From U.S.G.S. 7.5 min Quad, Penn DER Files and Field Inspection data

At Elevation 924.1

Initial Storage = 23 Acre feet

Pond Surface Area = 1.5 Acres

At Elevation 940, Area = 3.7 Acres

At Elevation 960, Area = 14.7 Acres

From Conic Method for Reservoir Volume

Flood Hydrograph Package (Hec-1)

Dam Safety Version (Users Manual)

$$H = \frac{3V}{A} = \frac{3(23)}{1.5} = 46 \text{ Feet}$$

Elevation where Area Equals Zero

924.1 - 46 = 878.1

AREA	$A	0.0	1.5	3.7	14.7
ELEVATION	$E	878.1	924.1	940	960.0

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Sheet _____ of _____

Job Colonial Dam #3 Job No. 7915-H

Subject Data Input

Made By JDH Date 4/28/92 Checked EHB Date 4/28/92

Overtop Parameters

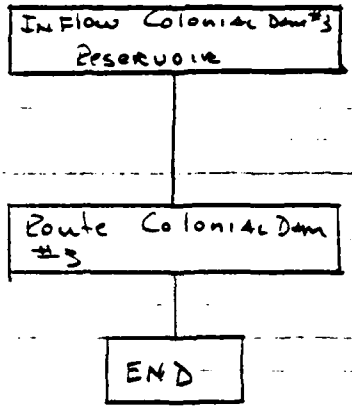
Top of Parapet Elevation (minimum) = 925.7

Length of Dam (excluding spillway) = 115.5

Coefficient of Discharge "C" = 3.1

$L max = 120.0 $V max = 930.0

Program Schedule



Sheet _____ of _____

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Job Spillway Rating Curve Job No 79153H
Subject Colonial Dam #3
Made By JPH Date 4/28/80 Checked EHB Date 4/29/80

Overflow Section on Right

$L = 39.7$ $Q = CLH^{3/2}$ width = 5'

Elevation	Head	C	Q_1 (cfs)
924.1	0		0
924.2	0.1	2.13	2.89
924.5	0.4	2.5	25.11
925.0	0.9	2.68	90.84
925.5	1.4	2.65	174.27
926.0	1.9	2.65	275.53
926.5	2.4	2.66	392.63
927.0	2.9	2.66	521.52
927.5	3.4	2.67	664.54
928.0	3.9	2.69	822.51
928.5	4.4	2.73	1000.30
929.0	4.9	2.78	1197.10
929.5	5.4	2.87	1429.76
930.0	5.9	3.08	1752.34

Values of C interpolated from table 5-3 page 5-46 "King and Brater", Handbook of Hydraulics

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Sheet _____ of _____

Job Spillway Rating Curve Job No 79153H

Subject Colonial Dam #3

Made By DH Date 4/28/80 Checked EHB Date 4/28/80

Overflow Section on Left

$L = 13.3$ feet $\quad Q_2 = CLH^{3/2}$

Elevation	Head	C	Q_2 (cfs)	Total Flow Q_T (cfs)
924.1	0		0	0
924.2	0		0	2.9
924.5	0.3	2.42	5.29	30.4
925.0	0.8	2.68	25.50	116.3
925.5	1.3	2.65	52.24	226.5
926.0	1.8	2.65	85.12	360.7
926.5	2.3	2.66	123.40	516.0
927.0	2.8	2.66	165.76	687.3
927.5	3.3	2.67	212.88	877.4
928.0	3.8	2.69	265.02	1087.5
928.5	4.3	2.72	322.57	1322.9
929.0	4.8	2.76	386.03	1583.1
929.5	5.3	2.84	460.88	1890.6
930.0	5.8	3.08	572.20	2324.5

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION     JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
    1              A1       NATIONAL PROGRAM FOR THE INSPECTION OF NON FEDERAL DAMS
    2              A2       HYDROLOGIC AND HYDRAULIC ANALYSIS OF COLONIAL NO. 3 DAM
    3              A3       PROBABLE MAXIMUM FLOOD PMF/UNIT HYDROGRAPH BY SNYDER'S METHOD
    4              B    300       0       5       0       0       0       0       0      -4       0
    5              B1     5
    6              J      1       9       1
    7              J1    1.      .9      .8      .7      .6      .5      .3      .2      .1
    8              K      0       1                                       1
    9              K1       INFLOW HYDROGRAPH FOR COLONIAL NO. 3 DAM
   10              M      1       1     1.5               1.5       1                       1
   11              P              19.4     102     120     130
   12              T                                                       1.0     .05
   13              W    2.0     0.5
   14              X   -1.5   -0.05     2.0
   15              K      1       2                                       1
   16              K1       ROUTING AT COLONIAL NO. 3 DAM
   17              Y                                1       1
   18              Y1     1                                               23.      -1
   19              Y4 924.1   924.2   924.5   925.0   925.5    926.   926.5    927.   927.5    928.
   20              Y4 928.5     929.    929.5   930.
   21              Y5   0.0     2.9    30.4   116.3   226.5   360.7   516.0   687.4   877.4  1087.4
   22              Y51322.9  1583.1  1890.6  2324.5
   23              $A   0.0     1.5     3.7    14.7
   24              $E 878.1   924.1   940.    960.
   25              $$ 924.1
   26              $D 925.7     3.1     1.5   115.5
   27              $L   5.0    99.8   115.5   120.0
   28              $V 925.7   926.5   926.7   930.0
   29              K     99
   30              A
   31              A
   32              A
   33              A
   34              A

                        PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

                                RUNOFF HYDROGRAPH AT          1
                                ROUTE HYDROGRAPH TO           2
                                END OF NETWORK


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

RUN  DATE: 12 MAY 80
RUN  TIME: 14.20.36


                        NATIONAL PROGRAM FOR THE INSPECTION OF NON FEDERAL DAMS
                        HYDROLOGIC AND HYDRAULIC ANALYSIS OF COLONIAL NO. 3 DAM
                        PROBABLE MAXIMUM FLOOD PMF/UNIT HYDROGRAPH BY SNYDER'S METHOD

                                        JOB SPECIFICATION
                          NQ      NHR     NMIN     IDAY      IHR     IMIN    METRC     IPLT     IPRT    NSTAN
                         300        0        5        0        0        0        0        0       -4        0
                                                  JOPER      NWT    LROPT    TRACE
                                                      5        0        0        0


                                MULTI-PLAN ANALYSES TO BE PERFORMED
                                    NPLAN= 1 NRTIO= 9 LRTIO= 1
                          RTIOS=    1.00     0.90     0.80     0.70     0.60     0.50     0.30     0.20     0.10

**********     **********     **********     **********     **********
```

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH FOR COLONIAL NO. 3 DAM

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

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	1.50	0.0	1.50	1.00	0.0	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.0	19.40	102.00	120.00	130.00	0.0	0.0	0.0

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.0	0.0	1.00	0.0	0.0	1.00	1.00	0.05	0.0	0.0

UNIT HYDROGRAPH DATA
TP= 2.00 CP=0.50 NTA= 0

RECESSION DATA
STRTQ= -1.50 QRCSN= -0.05 RTIOR= 2.00

UNIT HYDROGRAPH100 END-OF-PERIOD ORDINATES, LAG= 2.00 HOURS, CP= 0.50 VOL= 0.93

2.	8.	16.	26.	37.	49.	62.	76.	91.	106.
122.	138.	154.	170.	185.	198.	210.	220.	230.	237.
243.	248.	251.	251.	249.	243.	236.	229.	222.	215.
209.	202.	196.	190.	184.	179.	173.	168.	163.	158.
153.	149.	144.	140.	136.	132.	128.	124.	120.	116.
113.	109.	106.	103.	100.	97.	94.	91.	88.	86.
83.	80.	78.	76.	73.	71.	69.	67.	65.	63.
61.	59.	57.	56.	54.	52.	51.	49.	48.	46.
45.	43.	42.	41.	40.	38.	37.	36.	35.	34.
33.	32.	31.	30.	29.	28.	27.	27.	26.	25.

0 END-OF-PERIOD FLOW

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

SUM 25.22 23.34 1.88 248328.
(641.)(593.)(48.)(7031.87)

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

HYDROGRAPH ROUTING

ROUTING AT COLONIAL NO. 3 DAM

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

ROUTING DATA

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

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.0	0.0	0.0	23.	-1

STAGE	924.10	924.20	924.50	925.00	925.50	926.00	926.50	927.00	927.50	928.00
	928.50	929.00	929.50	930.00						
FLOW	0.0	2.90	30.40	116.30	226.50	360.70	516.00	687.40	877.40	1087.40
	1322.90	1583.10	1890.60	2324.50						
SURFACE AREA=	0.	2.	4.	15.						
CAPACITY=	0.	23.	63.	235.						
ELEVATION=	878.	924.	940.	960.						

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
924.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
925.1	3.1	1.5	116.

CREST LENGTH	5.	100.	116.	120.
AT OR BELOW ELEVATION	925.7	926.5	926.7	930.0

PEAK OUTFLOW IS 3274. AT TIME 17.58 HOURS

PEAK OUTFLOW IS 2947. AT TIME 17.58 HOURS

PEAK OUTFLOW IS 2619. AT TIME 17.58 HOURS

PEAK OUTFLOW IS 2292. AT TIME 17.58 HOURS

PEAK OUTFLOW IS 1964. AT TIME 17.58 HOURS

PEAK OUTFLOW IS 1637. AT TIME 17.58 HOURS

PEAK OUTFLOW IS 982. AT TIME 17.58 HOURS

PEAK OUTFLOW IS 655. AT TIME 17.58 HOURS

PEAK OUTFLOW IS 327. AT TIME 17.58 HOURS

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

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

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS								
				RATIO 1 1.00	RATIO 2 0.90	RATIO 3 0.80	RATIO 4 0.70	RATIO 5 0.60	RATIO 6 0.50	RATIO 7 0.30	RATIO 8 0.20	RATIO 9 0.10
HYDROGRAPH AT	1	1.50	1	3273.	2946.	2619.	2291.	1964.	1637.	982.	655.	327.
		(3.89)		(92.69)(	83.42)(	74.15)(	64.88)(	55.62)(	46.35)(	27.81)(	18.54)(	9.27)
ROUTED TO	2	1.50	1	3274.	2947.	2619.	2292.	1964.	1637.	982.	655.	327.
		(3.89)		(92.71)(	83.44)(	74.17)(	64.90)(	55.62)(	46.35)(	27.81)(	18.54)(	9.25)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	924.10	924.10	925.70
STORAGE	23.	23.	26.
OUTFLOW	0.	0.	280.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	928.97	3.27	32.	3274.	14.75	17.58	0.0
0.90	928.74	3.04	31.	2947.	14.25	17.58	0.0
0.80	928.50	2.80	31.	2619.	13.50	17.58	0.0
0.70	928.24	2.54	30.	2292.	12.33	17.58	0.0
0.60	927.98	2.28	30.	1964.	11.17	17.58	0.0
0.50	927.66	1.98	29.	1637.	10.33	17.58	0.0
0.30	927.01	1.31	28.	982.	8.00	17.58	0.0
0.20	926.58	0.88	27.	655.	5.83	17.58	0.0
0.10	925.86	0.16	26.	327.	2.17	17.58	0.0

Sheet _____ of _____

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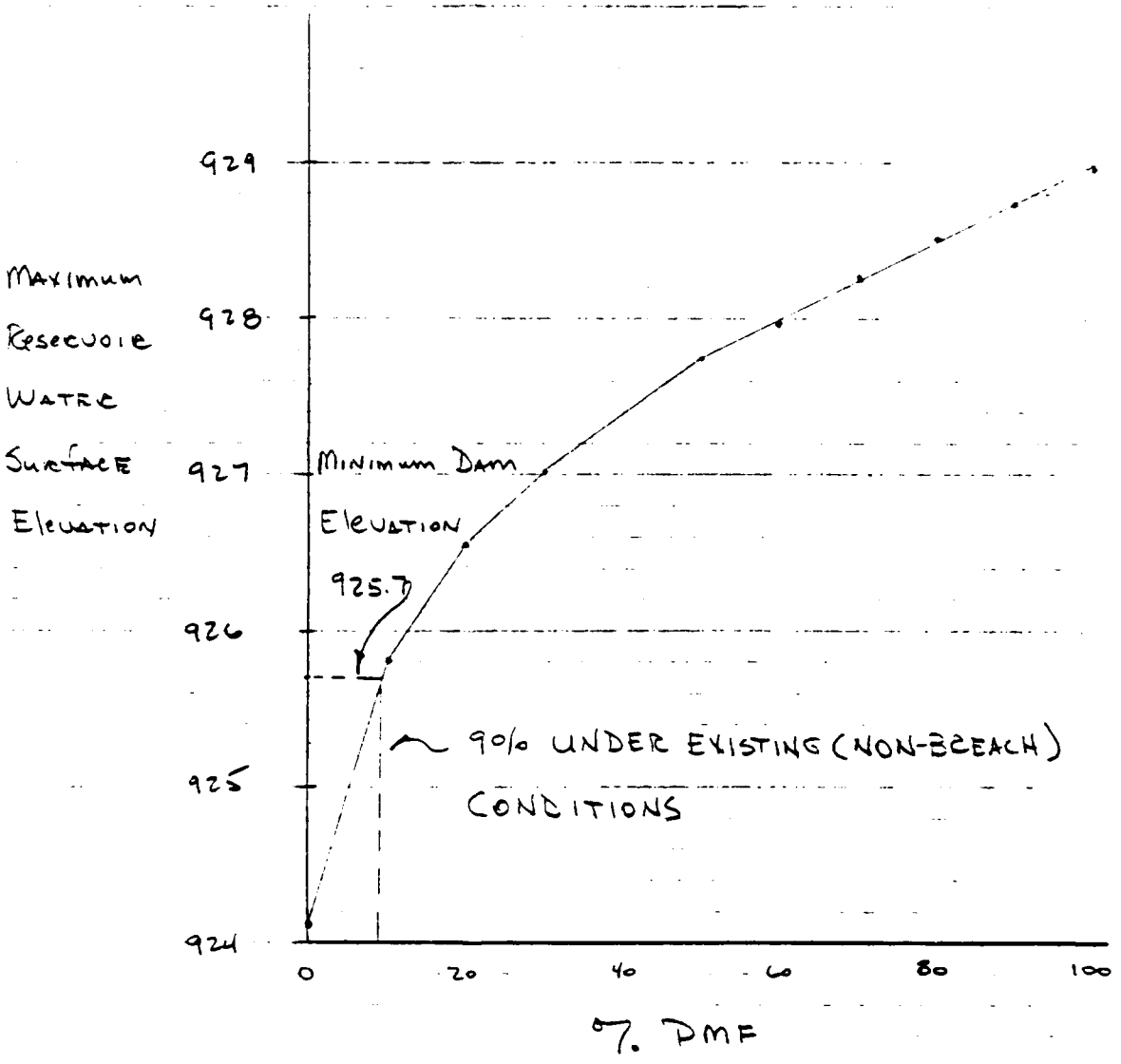
Job Colonial Dam #3 Job No. _____

Subject Spillway/Reservoir Rating Curve

Made By CDH Date 4/25/80 Checked EHB Date 4/29/80

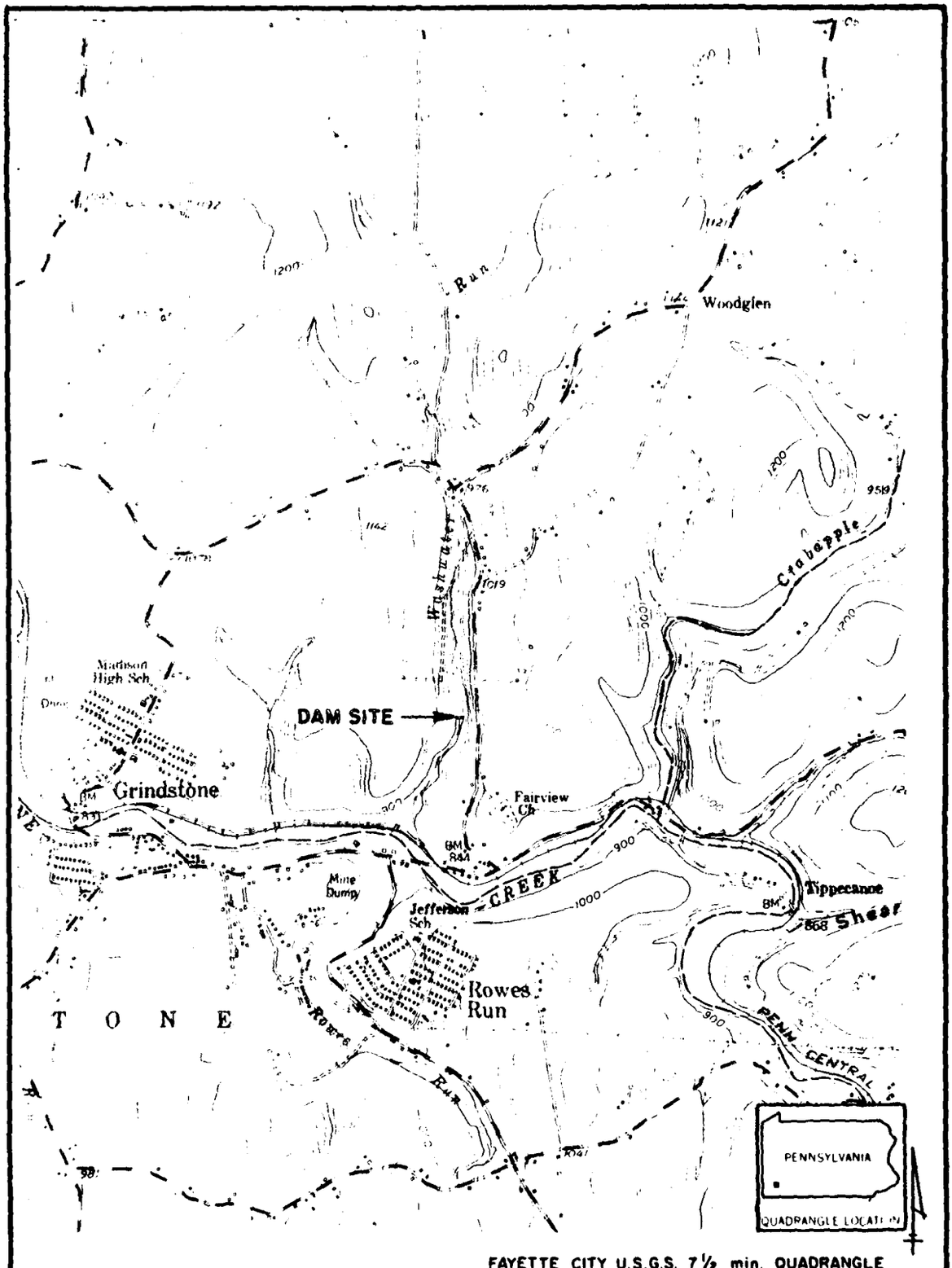
HYDROLOGIC PERFORMANCE PLOT



APPENDIX E

PLATES

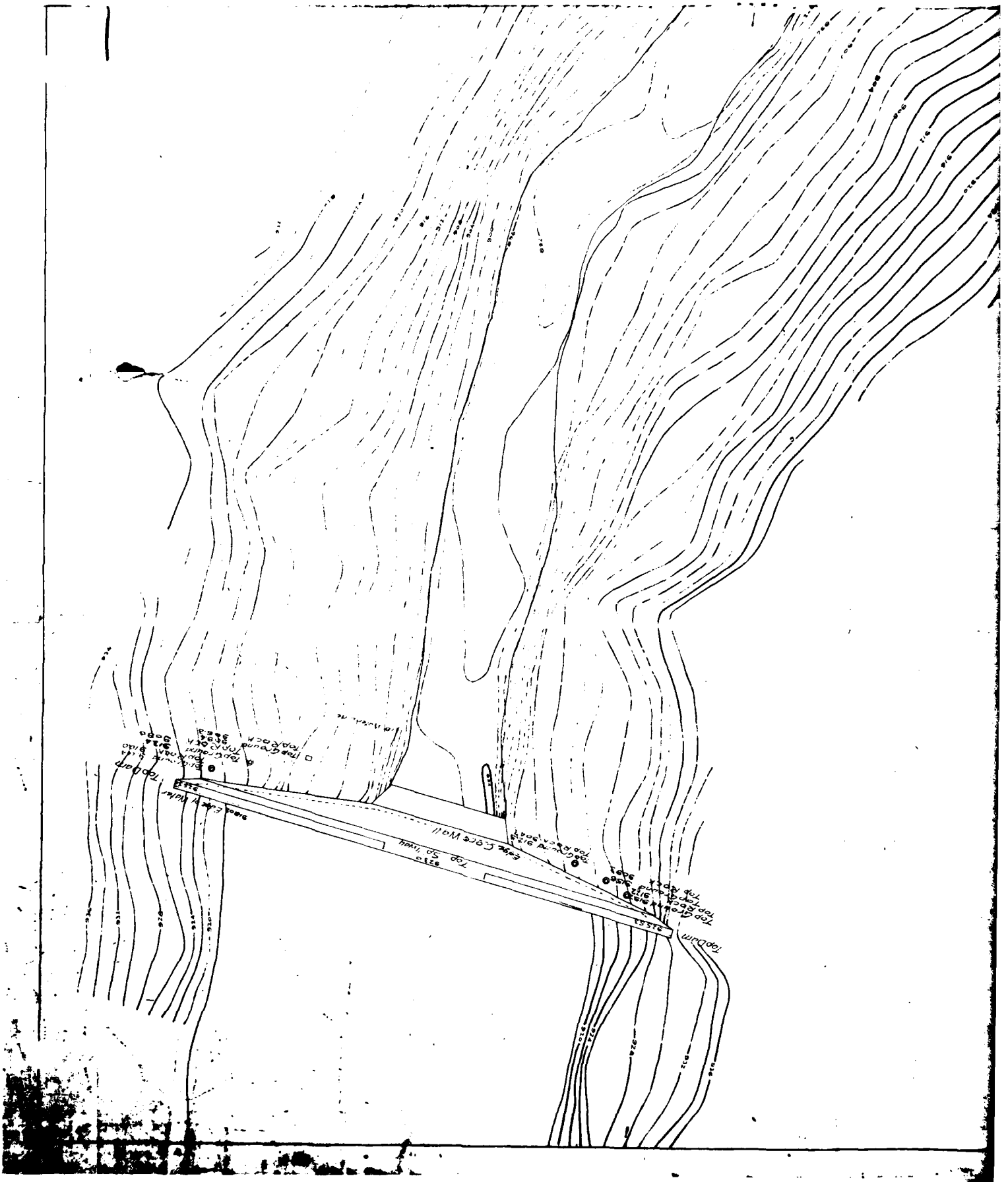
LIST OF PLATES



FAYETTE CITY U.S.G.S. 7½ min. QUADRANGLE

DATE: MAY 1980		COLONIAL DAM No.3 NATIONAL DAM INSPECTION PROGRAM	REGIONAL VICINITY MAP
SCALE: 1" = 2000'			
DR: JF	CK:	A. C. ACKENHEIL & ASSOCIATES, INC. CONSULTING ENGINEERS PITTSBURGH, PA., CHARLESTON, W. VA. & BALTIMORE, MD.	
DWG. NO. PLATE I			

10 7109 ALBANENE A. O. SMITH CO., PGH., PA.



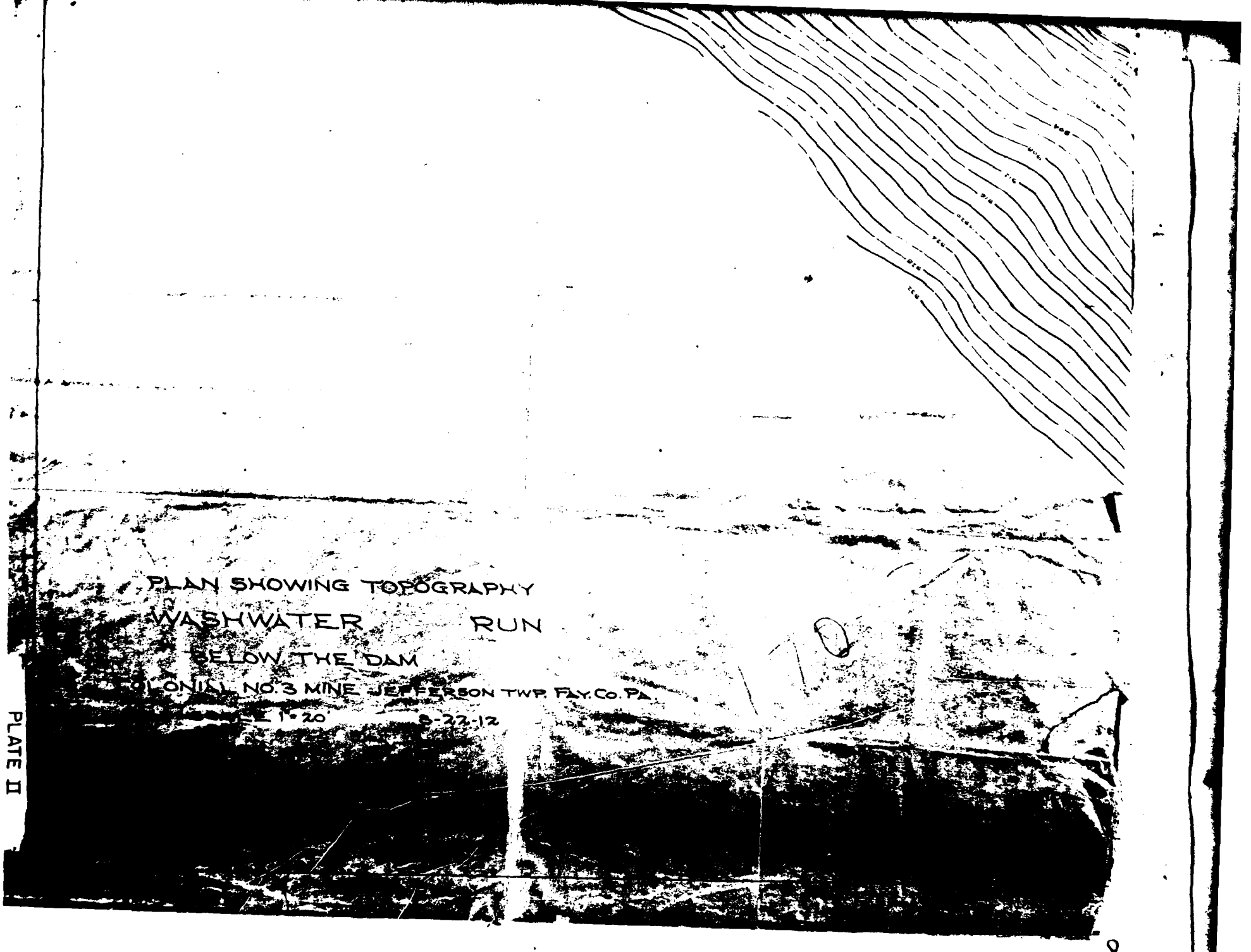
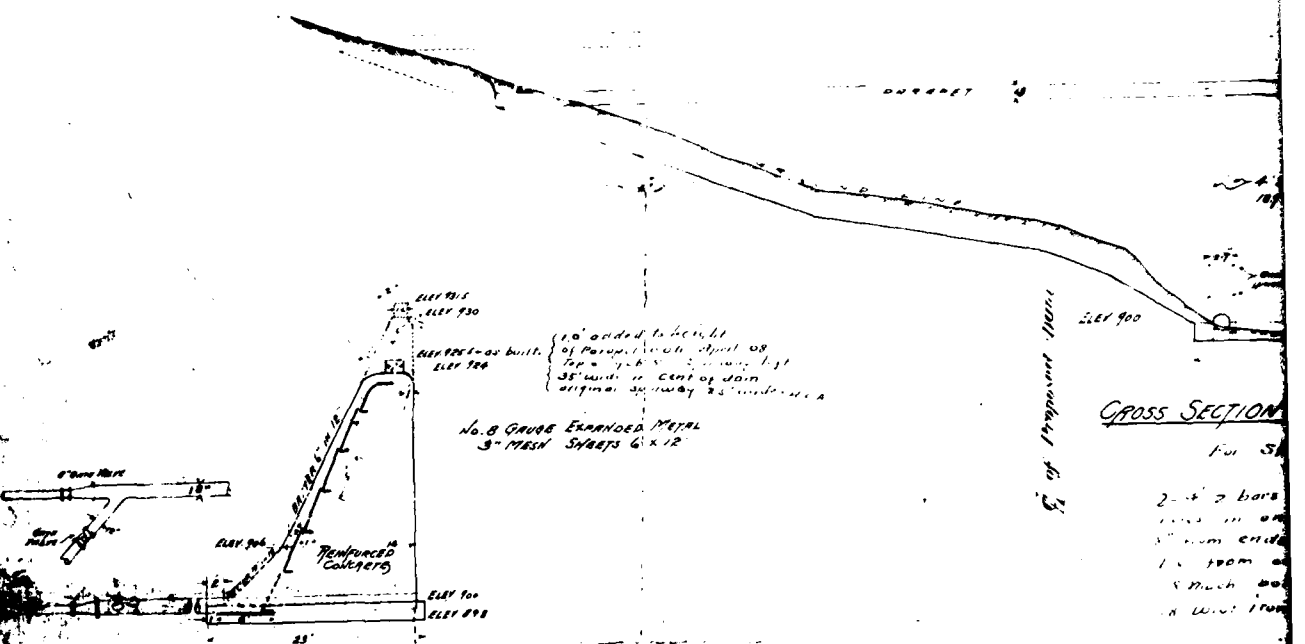
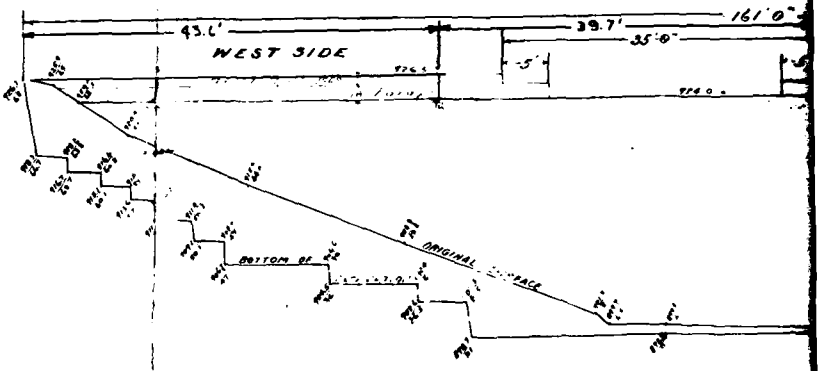

PLAN SHOWING TOPOGRAPHY
WASHWATER RUN
BELOW THE DAM
ONIA NO. 3 MINE JEFFERSON TWP. FAY. Co. PA.
1" = 20'
8-22-12

PLATE II

SECTION OF LIVE C
FOR PROP
1 IN =





STA. 0+00

CROSS SECTION OF DAM
AT BACK FACE STATION 0+
LOOKING UP STREAM
SHOWING ORIGINAL SURFACE & BOTTOM
SCALE 1"=1C

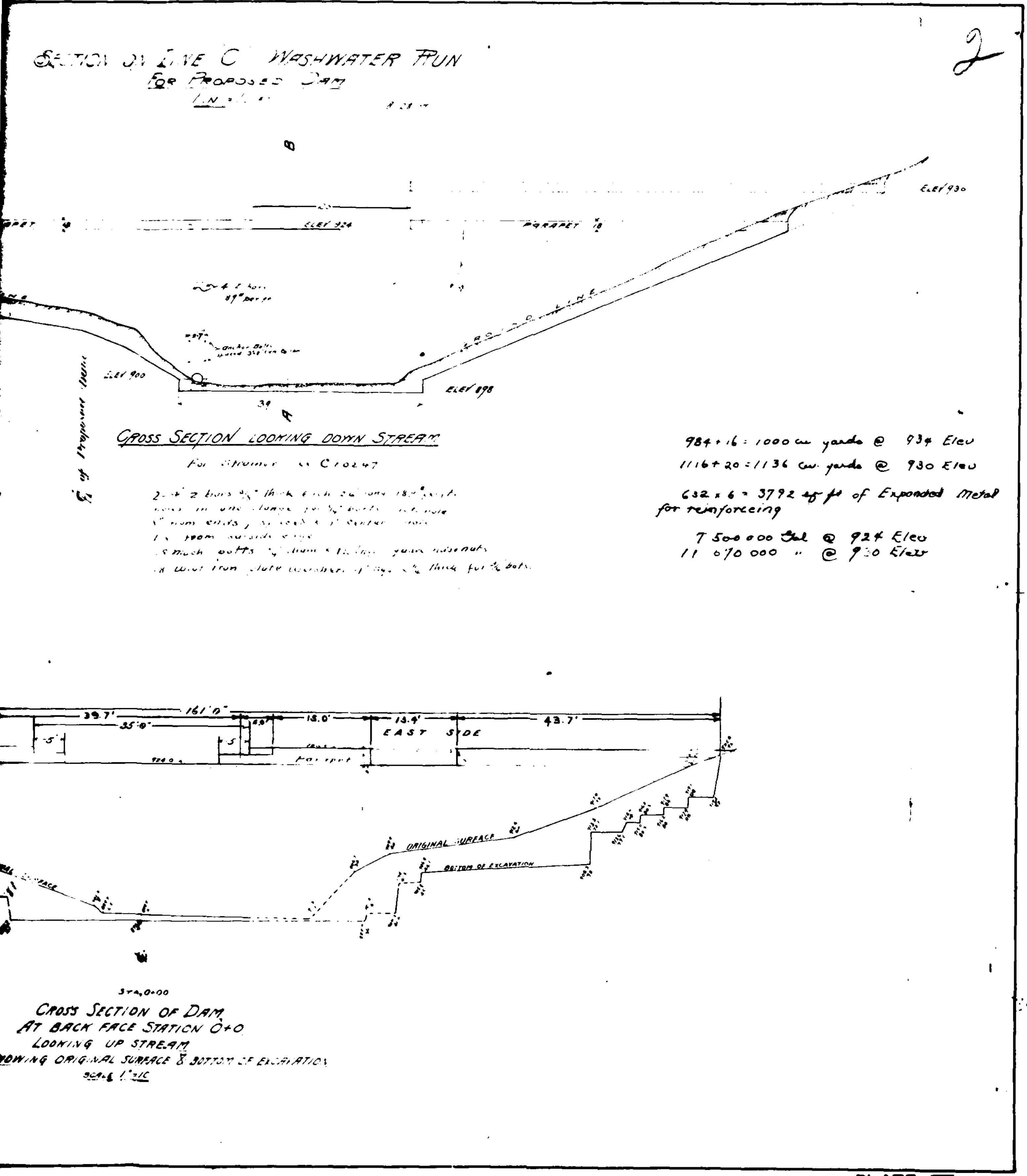

SECTION ON LINE C WASHWATER RUN
FOR PROPOSED DAM
ELEV 930
ELEV 924
PARAPET
ELEV 900
ELEV 898
GROSS SECTION LOOKING DOWN STREAM
984 + 16 = 1000 cu yards @ 934 Elev
1116 + 20 = 1136 cu. yards @ 930 Elev
632 x 6 = 3792 sq ft of Expanded Metal for reinforceing
7 500 000 Gal @ 924 Elev
11 670 000 " @ 930 Elev
39.7'
161' 0"
35' 0"
15.0'
13.4'
43.7'
EAST SIDE
ORIGINAL SURFACE
BOTTOM OF EXCAVATION
STA 0+00
CROSS SECTION OF DAM
AT BACK FACE STATION 0+0
LOOKING UP STREAM
SHOWING ORIGINAL SURFACE & BOTTOM OF EXCAVATION

PLATE III

APPENDIX F

GEOLOGY

GEOLOGY

Geomorphology

Colonial Dam No. 3 is located in the Pittsburgh Plateau section of the Appalachian Plateau physiographic province. This region is characterized by essentially flat lying strata at an altitude great enough to have permitted deep valley cutting by streams. Colonial Dam No. 3 is located along a narrow steep sided valley formed by Washwater Run, a tributary of Redstone Creek. The confluence of these two streams is about Elev. 810 ft.

Structure

General: The axis of the Lambert Syncline lies approximately 0.3 miles west of the dam. This syncline trends N14°E and plunges to the northeast. This syncline is typical of the alternating series of broad anticlines and synclines which characterize the Pittsburgh Plateau section. Based on estimates obtained from the "Coal and Surface Structure Map of Fayette County, Pennsylvania" the rock strata in the vicinity of the dam dip to the northwest.

Faults: No observations were made that would indicate faulting in the rocks outcropping around the dam site. In general, only a few evidences of faulting have been observed in all of Fayette County.

Stratigraphy

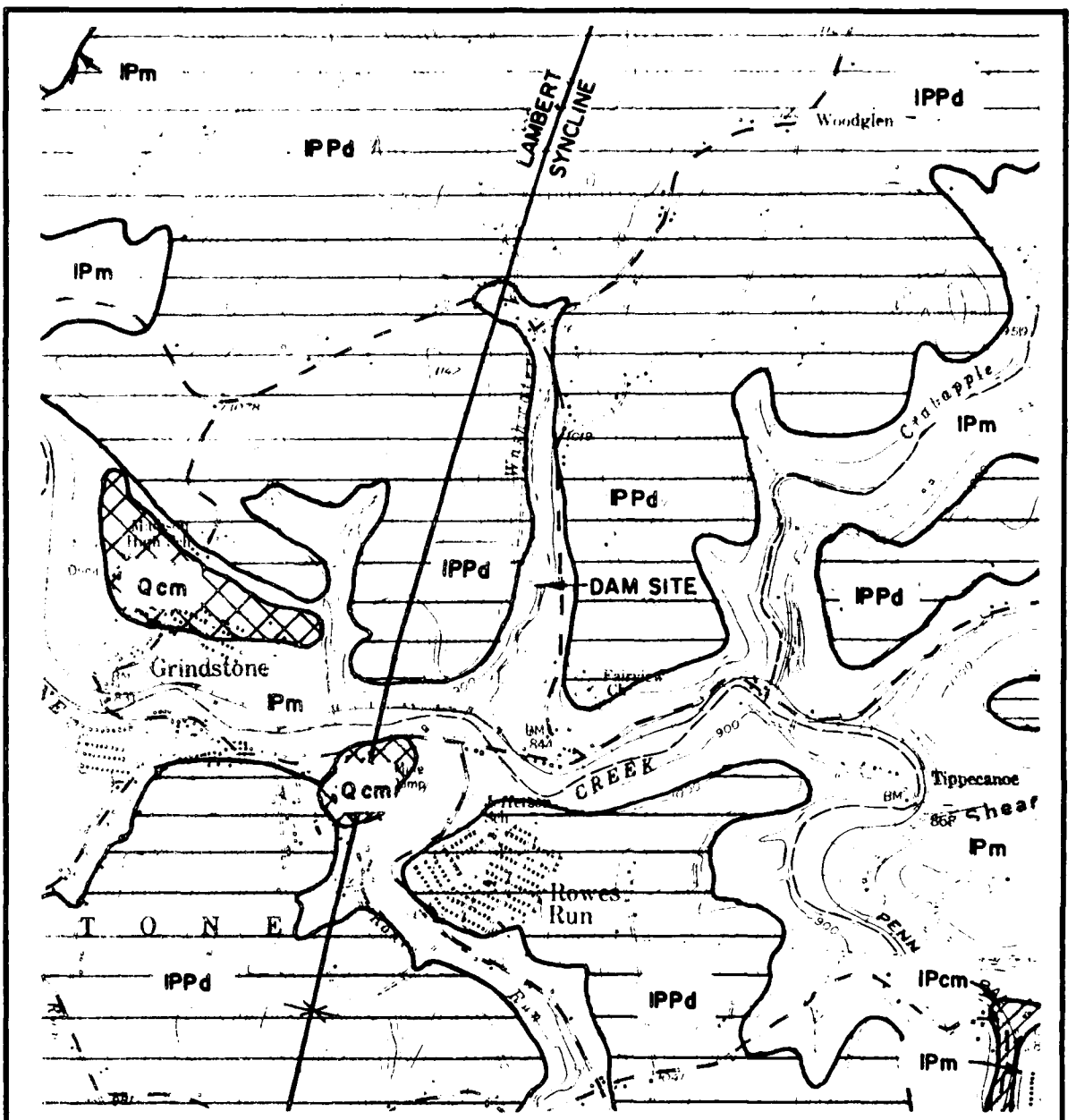
General: Rocks outcropping in the immediate vicinity of Colonial Dam No. 3 belong to the Uniontown Formation, Monongahela Group of Upper Pennsylvanian age; and the Waynesburg Formation, Dunkard Group of Permian age.

Waynesburg Coal: The Waynesburg Coal is the lowest bed in the Dunkard Group. It is often used a the markerbed to separate the Dunkard Group from the Monongahela Group. It outcrops at approximately Elev. 980 ft., or about 55 ft. above the reservoir surface. This coal is multiple bedded and about 5 ft. thick. It is separated into 2 or 3 benches by gray clay shale or plastic clay partings.

Arnoldsburg Sandstone: Rock excavated at the embankment foundation was described in the report cited in Section 2.1 b(1) as a sandstone overlain by a shale. The sandstone is believed to be the Arnoldsburg Sandstone of the Waynesburg Formation. This stratum has been described as a medium grained, soft gray brown sandstone occurring in thin to medium beds. Its thickness averages 10 feet in this area.

Uniontown Limestone: The Uniontown Limestone of the Uniontown Formation lies immediately above the Arnoldsburg sandstone. The limey shale beds at the base of this unit are believed to be the shales noted as occurring above the sandstone in a report cited in Section 2.1a(2). This unit averages 15 feet in thickness.

Upper Benwood Limestone: This unit occurs stratigraphically below the Arnoldsburg Sandstone and is composed of a light to dark gray fine grained interbedded with clay, limey shale and sandstone. Its average thickness is 50 feet.



FAYETTE CITY QUADRANGLE, FAYETTE COUNTY, PENNSYLVANIA

SCALE: 0 1/2 MILE 1:24000

CONTOUR INTERVAL 20 FT. DATUM IS MEAN SEA LEVEL

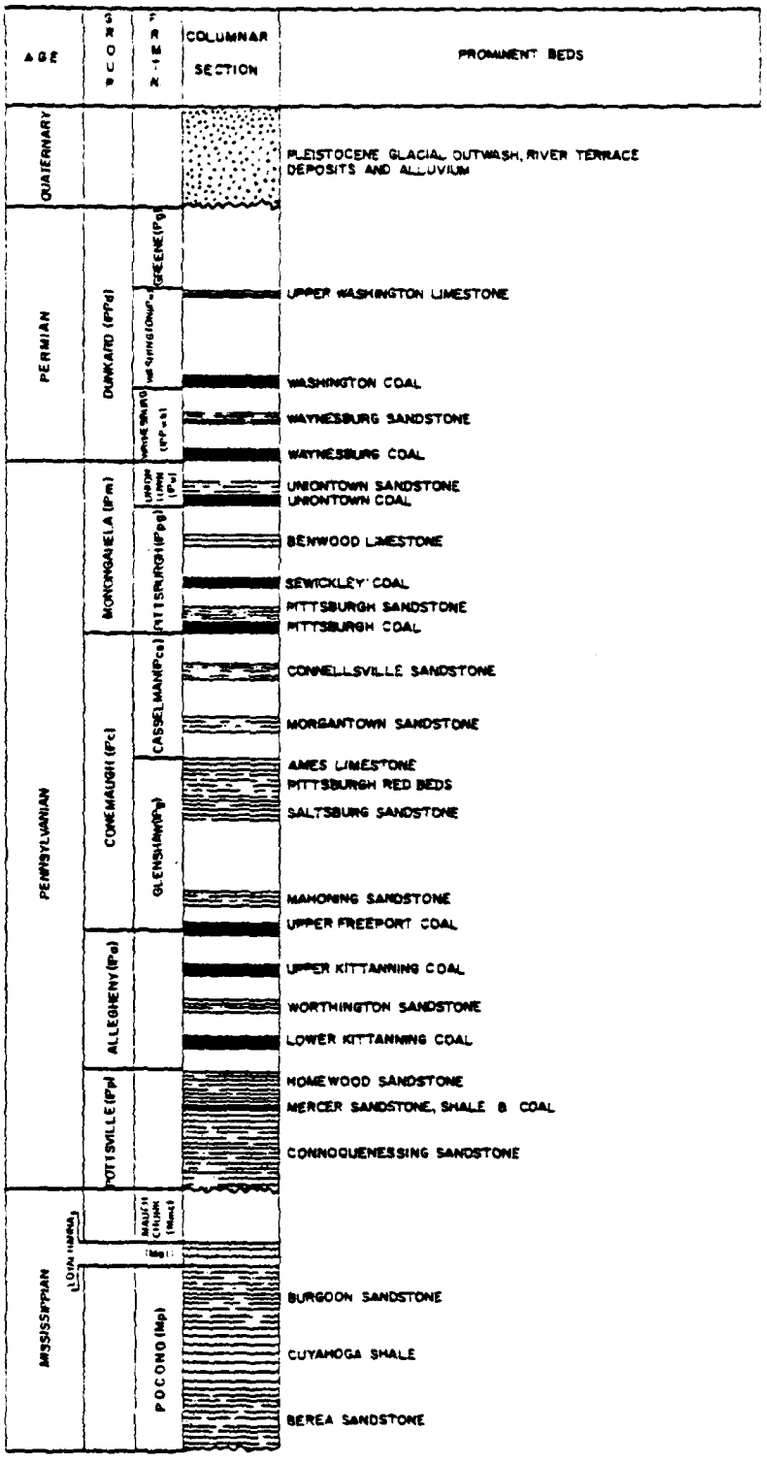
FORMATION CONTACT

DATA OBTAINED FROM PENNSYLVANIA TOPOGRAPHIC AND GEOLOGIC SURVEY, GEOLOGIC MAP OF FAYETTE COUNTY PENNSYLVANIA, 1940 and COAL AND SURFACE STRUCTURE MAP OF FAYETTE COUNTY, PENNSYLVANIA, 1940

DATE: MAY 1980		COLONIAL DAM No.3 NATIONAL DAM INSPECTION PROGRAM	GEOLOGIC MAP
SCALE: 1" = 2000'			
DR:	CK:	A. C. ACKENHEIL & ASSOCIATES, INC. CONSULTING ENGINEERS PITTSBURGH, PA., CHARLESTON, W. VA. & BALTIMORE, MD.	

10 7100 ALBANENE A. & B. SMITH CO., PGH., PA.

PR



DATE: MAY 1980		COLONIAL DAM No. 3 NATIONAL DAM INSPECTION PROGRAM	GEOLOGIC COLUMN
SCALE: NONE			
DR: JF	CK: JPH	A. C. ACKENHEIL & ASSOCIATES, INC. CONSULTING ENGINEERS PITTSBURGH, PA., CHARLESTON, W. VA. & BALTIMORE, MD.	

APPENDIX G

STABILITY ANALYSES

LIST OF ANALYSES

1240745

STRENGTH OF SECTION.

The forces assumed as acting on the section are:-

1 - Weight of masonry, taken as 145 pounds per cubic foot, and acting vertically.

2 - The horizontal pressure of the water against the vertical upstream rear face of the dam, with water at elevation 926.5.

3 - Upward water pressure on the base, considered as 2/3 that due to the hydrostatic head, applied at the heel, decreasing uniformly to "0" at the toe, and acting 1/3 the distance from the heel to the toe.

4 - No ice action, the lip of the spillway being rounded so that ice cannot cling to it.

The overflow section of the dam was investigated, it being under more extreme conditions than the section containing the parapet. The forces, moments, etc. acting on this dam at various elevations are shown in the following tabulation:-

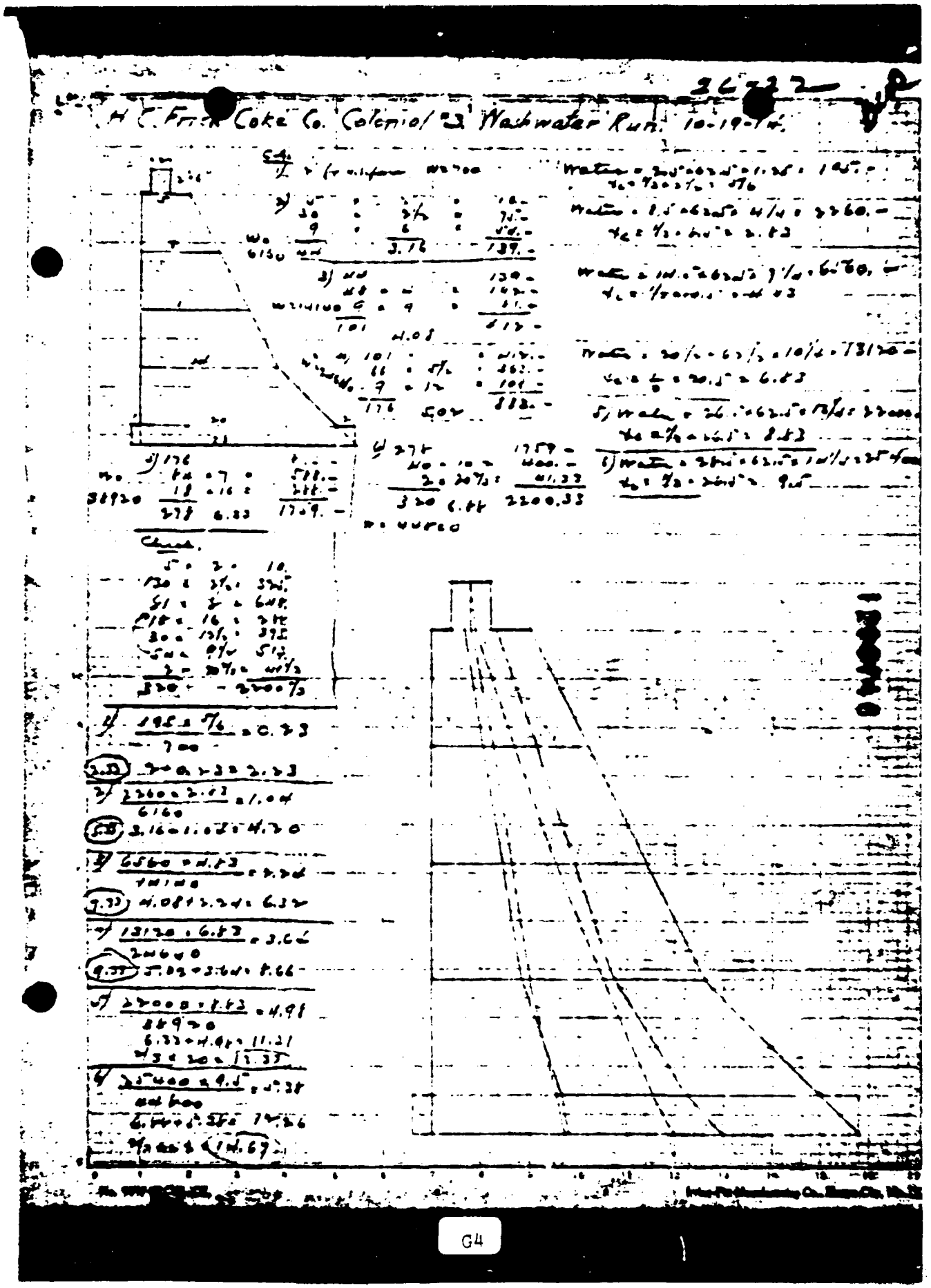
TABLE.

(1) - Elevation of Joint.	918	912	906	900
(2) - Elevation water surface.	926.5	926.5	926.5	926.5
(3) - " top of dam.	926	926	926	926
(4) - Width at elevation of (3) - in ft.	5	5	5	5
(5) - " " " " (1) - " "	8	11	14	20
(6) - Weight of masonry above joint - in lbs.	5600	12840	24740	39530
(7) - Lever arm of masonry about toe - ft.	4.68	6.84	8.88	13.58
(8) - Upward pressure of water - in lbs.	1420	3380	5960	11040
(9) - Lever arm about toe - in ft.	5 1/3	7 1/3	9 1/3	13 1/3
(10) - Net Vertical Forces (6) - (8) in lbs.	4180	10520	18760	28490
(11) Distance of line of action of (10) from toe.	4.44'	6.59'	8.74'	13.70'
(12) - Horizontal pressure of water - in lbs.	2040	6840	12980	21780
(13) - Lever arm of (12) about toe. — ft	2.46'	4.88	6.66	8.48'
(14) - Resultant pressure on joint. — lbs	4600	12590	22680	[illegible]

(15) - Distance from toe at which R cuts joint.	3.24	3.90	4.14	7.04
(16) - Distance from middle third (- indicates outside)	0.57	0.23	-0.53	0.37
(17) - Total overturning moment - ft. lbs.	12640	53720	142000	836400
(18) - " resisting " - " "	26220	94800	217700	5.7000
(19) - Ratio . (18)/(17)	2.07	1.76	1.56	1.80
(20) - Ratio..... (15)(21)/(11)(3)	3.66	2.48	1.90	2.06
(21) - Ratio.....(12)/ (10)	.48	.606	.689	.763
(22) - Pressure at toe, Reservoir full - tons per sq. ft.....	.41	....	.....	1.34
(23) - Pressure at heel, Reservoir empty - tons per sq. ft.....	.53	.....	.....	2.05

Under the above conditions, with the reservoir full, the resultant cuts the joints investigated inside the middle third point, with one exception, namely section 906, where it falls 0.53 ft. outside; however, for section 900 it is again well inside. For reservoir empty the resultant is within the middle third, with the exception of the joint at elevation 900, where it is 0.25 ft. outside. The tension caused by the above is practically negligible. Line 19 indicates the ratio of resisting to overturning moments, and shows the factor of safety possessed by the section against rotation about its toe.

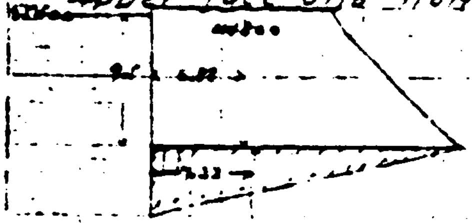
Line 21 shows the ratio of horizontal to vertical forces, and indicates the resistance of the section to sliding on the base. The maximum pressure on the toe is 1.34 tons per square foot, with the reservoir full, and on the heel 2.05 tons per square foot, with the reservoir empty, which are very moderate. In line 21 it is seen that for the section at elevation 900, the tangent of the angle at which the resultant cuts the base is greater than allowable, indicating that the dam is about to slide on its base. This is due to assuming an upward hydrostatic pressure on the base, even though the foundation was grouted, and very little water there encountered; it neglects any strength being developed by the concrete, due to the embedded stones, or roughening of the base. In my opinion, the section is sufficiently heavy.



H. C. Frick Coke Co. Colonial "A" Washwater Run. 10-19-14.

H. C. Frick Coke Co. Colonial #2. Cond. 10-20-14.

Assume upward pressure due to 3/4 full head at upper face and none at toe and figure resultant



$28.5 \times 62.5 \times 3/4 = 1335$ #

$\frac{1335 \times 22}{2} = 14685$ # upward pressure

44800	6.88	309000
14685	7.33	107200
30115	6.70	201800

$\frac{25400 \times 9.5}{30115} = 8.02$

$6.70 + 8.02 = 14.72$

$2/3 \times 22 = 14.67$

Max. Pressure at Toe

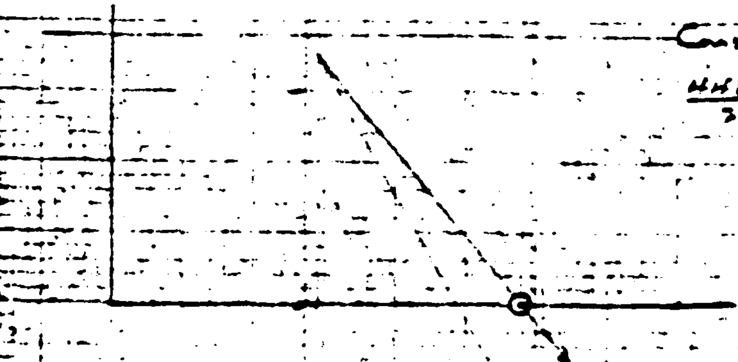
$\frac{W}{2}\left(1 + e\frac{6}{2}\right)$

$\frac{44800}{22}\left(1 + 1.26\frac{6}{22}\right)$

$2036(1 + 0.34) = 2765$ #

Considering upward pressure

$\frac{44800}{22}(\ldots) = \ldots$



Spillway Capacities.

1) $Q = \frac{40}{3} \times 39.5 \times 2.5^{3/2}$
$= \frac{395 \times 3.95}{3}$
$= 521$ cfs.

2) $Q = \frac{10}{3} \times 5 \times 1$
$= 16\,2/3$ cfs

3) $Q = \frac{10}{3} \times 13 \times 2^{3/2}$
$= \frac{130 \times 3.95}{3}$
$= 171$

521
17
171
709 cfs + 1.4 = 506 cfs per sq mi

Flow over dam in 1912.

25' 2' deep	10' 1½	[illegible]
$\frac{40}{3} \times 25 \times 2^{3/2}$ = 83⅓ × 5.2 = 414	$\frac{10}{3} \times 10 \times 1.5$ = 33⅓ × 1.13 = 61	$\frac{40}{3} \times 126 \times$ … = 420 × 354 …

414
61
148
623

$\frac{623}{1.4} = 445$

Sheet 1 of 12

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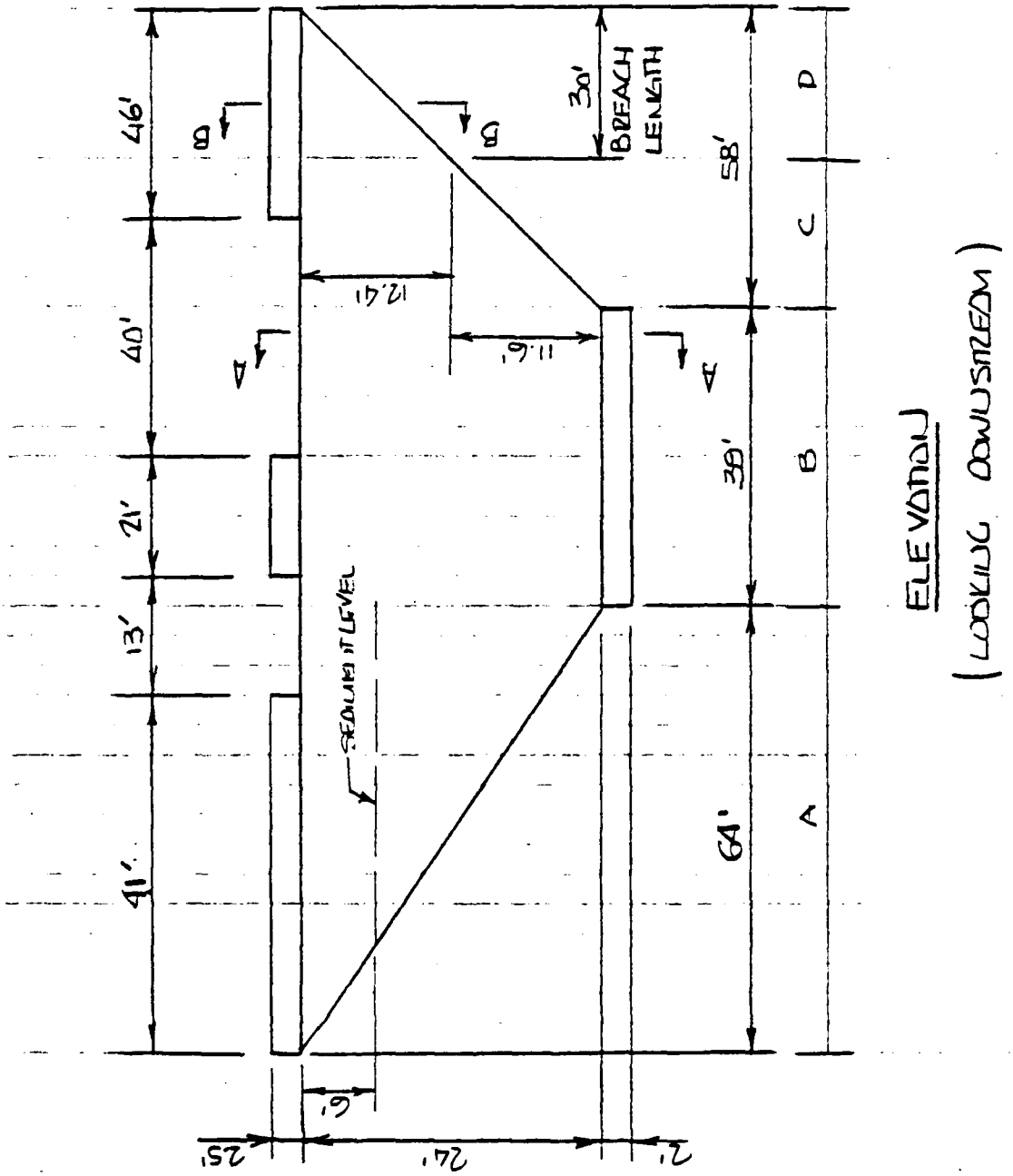
Job COLONIAL MON JD 3 Job No. 7953H

Subject SLIDING STABILITY

Made By JEB Date 4/16/80 Checked SGM Date 4/27/80



ELEVATION
(LOOKING DOWNSTREAM)

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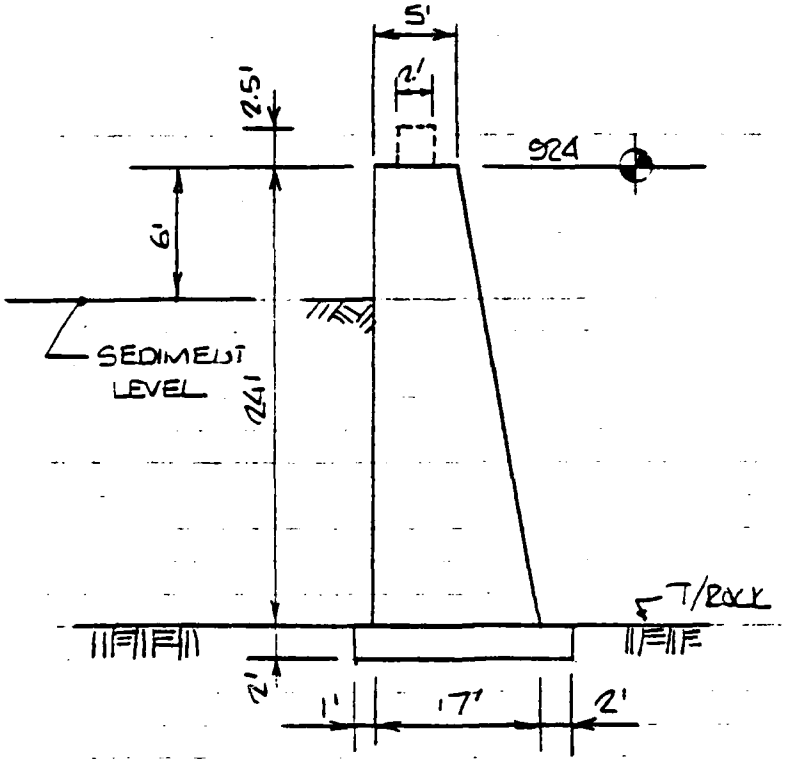
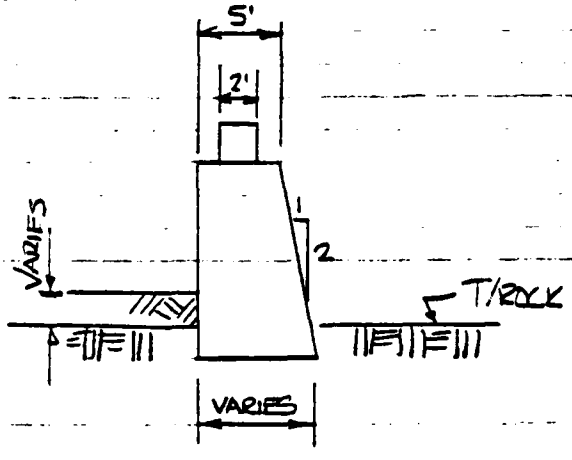


SECTION A-A



SECTION B-B

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Job _____ Job No. 79153H

Subject _____

Made By JEB Date 4/26/80 Checked SAM Date 4/27/80

WEIGHT OF DAM

SECTION A-A Area of Concrete = 2(20) + ½(24)(5+17)
= 304 sf

Area of Concrete without base = 264 sf

VOLUME OF CONCRETE

LENGTH A $V = \frac{1}{3}bh$

$= \frac{1}{3}(264)(64) =$ 5632 cf

LENGTH B $V = 39(304) =$ 11856 cf

LENGTH C-D $V = \frac{1}{3}bh$

$= \frac{1}{3}(264)(59) =$ 5104 cf

PARAPET $V = 2(2.5)(41+21+46) =$ 540 cf

TOTAL VOLUME = 23132 cf

TOTAL WEIGHT @ 145 pcf* = 3354 kips

AREA OF BASE

LENGTH A $W_1 = 5$ $W_2 = 17$ $L = \sqrt{24^2+64^2} =$ 68.4 FT

$A_A = \frac{68.4}{2}(5+17) =$ 752 SF

LENGTH B_1 AND B_3 $W_1 = 2$ $W_2 = 20$

$A_{B_1} = A_{B_3} = 2(20) =$ 40 SF

LENGTH B $W_1 = 39$ $W_2 = 20$

$A_B =$ 780 SF

* Unreinforced concrete

Sheet 3A of 12

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LENGTH C $W_1 = 17$ $W_2 = 10.8$ * $L = \sqrt{29^2 + 11.6^2} = 30.3$

$$A_C = \frac{30.3}{2}(17 + 10.8) = 421 \text{ SF}$$

AREA OF BASE = 2033 SF

* ERROR NOTED ON CHECK $W_2 = 11.2$
SUBSEQUENT CALCULATIONS NOT CHANGED
AS ERROR HAS NO EFFECT ON FINAL ANSWER

JEB

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Job _____ Job No 7953H

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Made By JEB Date 4/26/80 Checked SGM Date 4/27/80

SLIDING RESISTANCE

Assumptions: Neglect weight of water above dam crest

Assume $\mu = 0.70$ as per NAVFAC DM-7 for mass concrete on clean sound rock. See Table 10-1.

Breach length has no resistance to sliding or uplift pressure.

Foundation uplift varies from full hydrostatic pressure at upstream edge to zero at the downstream edge.

Pool level is at:
(1) Top of parapet
(2) 5' above parapet

(1) POOL LEVEL AT TOP OF PARAPET:

LENGTH A

Base length at right = 17' $P_{uplift} = \frac{1}{2}(62.4)(26.5)(17)$

$= 14.1\ K$

Base length at left = 5' $P_{uplift} = \frac{1}{2}(62.4)(2.5)(5)$

$= 0.4\ K$

Uplift over length A

$$P_{UP}(A) = \frac{L}{3}\left(P_R + \sqrt{P_L P_R} + P_L\right)$$

$= 360\ K$

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LENGTH B

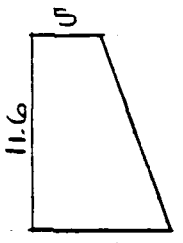
Base length = 20' $P_{uplift} = \frac{1}{2}(62.4)(23.5)(20)$

$= 17.5K/FT$

Uplift over Length B

$P_{UP(B)} = 17.8(39) = 694K$

LENGTH C



Base length at left = 17' $P_{uplift} = 14.1K$

Base length at right = 10.8' $P_{uplift} = \frac{1}{2}(62.4)(14.1)(10.8)$

$= 4.9K$

Uplift over Length C

$P_{UP(C)} = \frac{28}{3}\left(14.1K + 4.8K + \sqrt{(14.1)(4.8)}\ K\right) = 253K$

Total Uplift = 360K + 694K + 253K = 1307K

Effective normal load on foundation

$\bar{N} = 3354K - 1307K = 2047K$

$R_{SLIDING} = 2046K(0.7)$
$= 1433K$

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(2) POOL LEVEL 5' ABOVE PONDET

LENGTH A

Right end $P_{uplift} = \frac{1}{2}(62.4)(31.5)(17) = 16.7K$

Left end $P_{uplift} = \frac{1}{2}(62.4)(7.5)(5) = 1.2K$

Uplift over Length A $= \frac{64}{3}\left(16.7+1.2+\sqrt{16.7(1.2)}\right)K$

$= 4.77K$

LENGTH B

Uplift over Length B $= 39\left(\frac{1}{2}\right)(62.4)(33.5)(20)$

$= 815K$

LENGTH C

Left end $P_{uplift} = 16.7K$

Right end $P_{uplift} = \frac{1}{2}(62.4)(19.1)(10.8)$

$= 6.4K$

Uplift over Length C $= \frac{28}{3}\left(16.7K+6.4K+\sqrt{16.7(6.4)}\right)K$

$= 312K$

Total Uplift for (2) $= 4.77K + 815K + 312K = 1604K$

$N = 3354K - 1604K = 1750K$

$R_{SLIDING} = 1225K$

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PASSIVE RESISTANCE

Assumptions: Dam is constructed a minimum two feet into competant rock

Rock has $\phi = 45°$ $C = 0$ $\gamma = 140$ pcf

NO passive resistance exist over breach length

$$K_p = \tan^2(45 + \frac{\phi}{2})$$

$$= \tan^2(67.5°) = 5.8$$

$$P_p = \frac{1}{2} K_p \gamma h^2$$

$$= \frac{1}{2}(5.8)(140)(2)^2$$

$$= 2K$$

TOTAL RESISTANCE TO SLIDING

(1) 1435K

(2) 1227K.

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NATIONAL DAM INSPECTION PROGRAM. COLONIAL DAM NUMBER 3, (NDI NU--ETC(U)
MAY 80 J P HANNAN DACW31-80-C-0026
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Made By JEB Date 4/26/80 Checked SGM Date 4/27/80

DRIVING FORCES

Assumptions: Pool level is at:
(1) Top of Parapet
(2) 5' above parapet

Parapet is continuous across top of dam

Fluid drag forces are neglected.

Sediment has $\gamma = 60$ pcf $\phi = 30°$ $C = 0$ psf

(1) POOL LEVEL AT TOP OF PARAPET

LENGTH A – WATER

$$f_{RIGHT} = \tfrac{1}{2}(62.4)(26.5)^2 = 21.9K$$

$$f_{LEFT} = \tfrac{1}{2}(62.4)(17.5)^2 = 0.2K$$

$$F_A = \frac{64}{3}\left(21.9K + 0.2K + \sqrt{21.9(0.2)}\right)$$

$$= 516K$$

LENGTH B – WATER

$$f = \tfrac{1}{2}(62.4)(25.5)^2 = 25.3K$$

$$F_B = 39(25.3K) = 997K$$

LENGTH C-D – WATER

$$f_{LEFT} = 21.9K$$

$$f_{RIGHT} = 0.2K$$

$$F_{C\text{-}D} = \frac{58}{3}\left(21.9 + 0.2 + \sqrt{21.9(0.2)}\right)$$

$$= 468K.$$

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Job _____ Job No. 791534

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Made JEB Date 4/26/93 Checked SGM Date 4/27/93

Total Hydrostatic Pressure Load

$F_{H(1)} = 197.1K$

LENGTH A - SEDIMENT $K_A = \tan^2(45 - \frac{\phi}{2}) = 0.9$ $\phi = 3°$

$f_{RIGHT} = \frac{1}{2}(57-62.4)(0.9)(18)^2 = 2.6K$

$f_{LEFT} = 0$ $L_A = \frac{18}{24}(64) = 48.0$

$S_A = \frac{1}{3}(48)(2.6) = 42K$

LENGTH B -

$f = 2.6K$

$S_B = 2.6(39) = 102K$

LENGTH C-D

$f_{LEFT} = 2.6K$

$f_{RIGHT} = 0.K$ $L_{CD} = \frac{18}{24}(58) = 43.5$

$S_{CD} = \frac{1}{2}(2.6)(43.5) = 38K$

Total Active Sediment Pressure

$S = 182K$

TOTAL DRIVING FORCE (1)

$F_{(1)} = 197.1K + 182K = 215.3K$

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(2) POOL LEVEL 5' ABOVE TOP OF PARAPET

LENGTH A - WATER

$f_{TRIGHT} = \frac{1}{2}(62.4)(31.5)^2 = 31.0K$

$f_{LEFT} = \frac{1}{2}(62.4)(7.5)^2 = 1.8K$

$F_A = \frac{64}{3}\left(31.0 + 1.8 + \sqrt{31.0(1.8)}\right)$

$= 859\ K$

LENGTH B

$f = \frac{1}{2}(62.4)(33.5)^2 = 35.0K$

$F_B = 39(35K) = 1365K$

LENGTH CD

$f_{LEFT} = 31.0K$

$f_{RIGHT} = 1.8K$

$F_D = \frac{56}{3}\left(31.0 + 1.8 + \sqrt{31(1.8)}\right)$

$= 779K$

Total Hydrostatic Pressure Load

$F_{H(2)} = 859K + 1365K + 779K = 3003K$

TOTAL DRIVING FORCE (2)

$F_{(2)} = 3003K + 182K = 3185K$

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Made By JEB Date 5/12/80 Checked SGM Date 5/23/80

SAFETY FACTORS AGAINST SLIDING

$$R_R = V\tan(\phi+\alpha) + \frac{cA_B}{\cos\alpha\,(1-\tan\phi\tan\alpha)}$$

FOR $\alpha = 0$ (HORIZONTAL BASE)

$$R_R = V\tan\phi + cA_B$$

FOR $\tan\phi = 0.7$

$$A_B = 2033$$

$$R_R = 0.7V + 2033c$$

FOR THE POOL AT THE PORADET $0.7V = 1435K$

FOR A SLIDING SF = 3

$$R_R = 2153(3)K = 1435K + 2033c$$

AND $C = 2.47\,KSF = 17\,PSI$

FOR THE POOL LEVEL 5' ABOVE THE PORADET, SF = 3

$$R_L = 3(3185)K = 1227K + 2033c$$

$$= 4026\,PSF = 28\,PSI$$

FOR SF = 3, A COHESIVE BOND OF BETWEEN 17 AND 28 PSI MUST BE MAINTAINED OVER THE ENTIRE BASE. SINCE THIS IS NOT AN UNREASONABLE VALUE, THE STRUCTURE CAN BE ASSUMED TO BE SAFE AGAINST SLIDING FAILURE.

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FOR THE SDF = ½ DMF @ EL 927.7

THEN C = 17 PSI @ EL 926.5

C = 28 PSI @ EL 931.5

THEN

C = 19.6 PSI. SAY 20 PSI. FOR

ΔU SF = 3

Sheet 1 of 6

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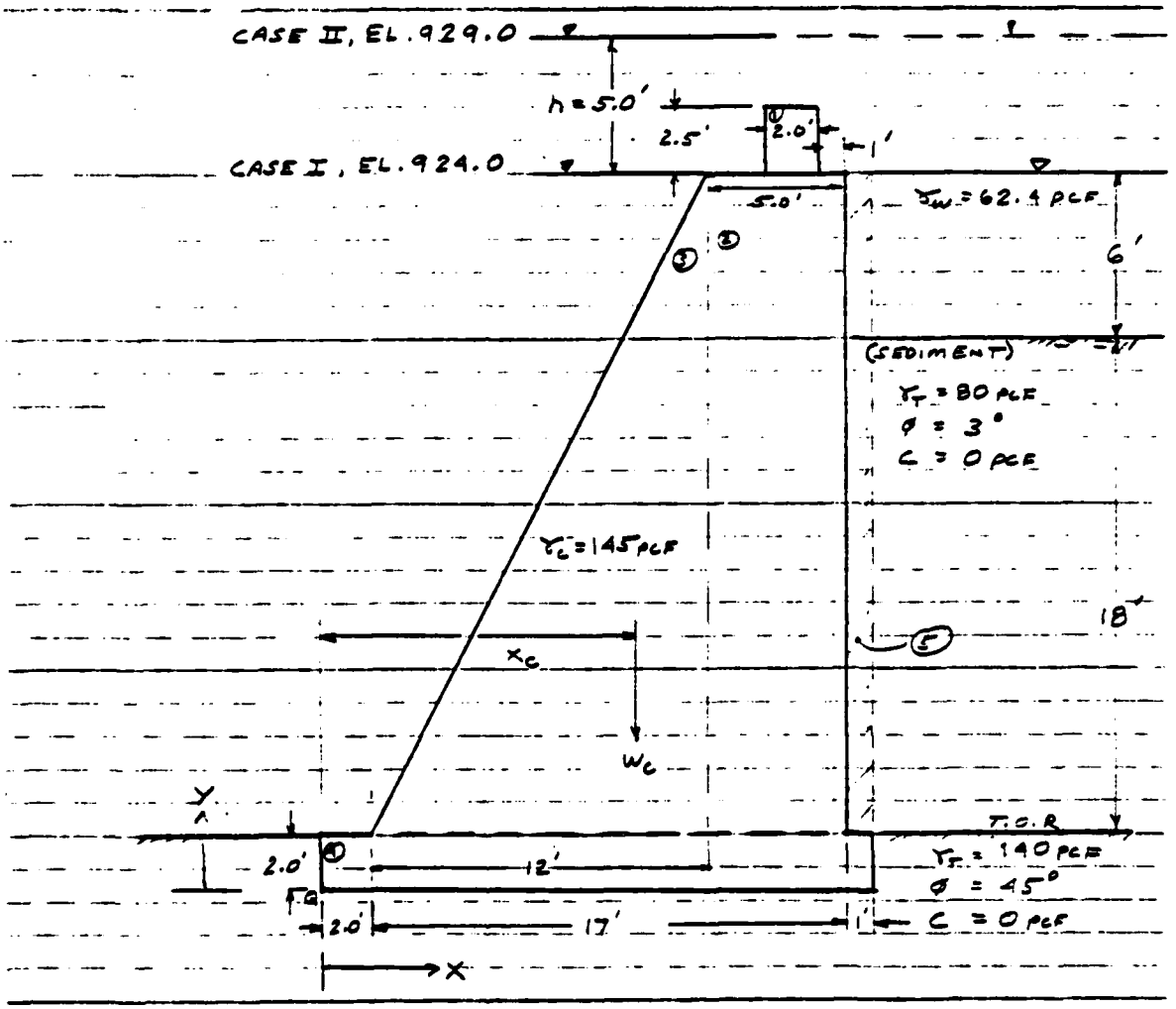
Job COLONIAL DAM No. 3 Job No. 79153 4

Subject FACTOR OF SAFETY AGAINST OVERTURNING

Made By SGM Date 4/28/80 Checked EHB Date 4/29/80



$K_A = \frac{1-\sin\phi}{1+\sin\phi}$ $K_P = 1/K_A$

@ 3° $K_A = \frac{1-\sin 3^\circ}{1+\sin 3^\circ} = 0.90$

@ 45° $K_A = \frac{1-\sin 45^\circ}{1+\sin 45^\circ} = 0.172$ $K_P = 1/0.172 = 5.828$

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Job _____ Job No. 79153 H

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Made By SGM Date 7/28/80 Checked EHB Date 7/29/80

WEIGHT OF GRAVITY SECTION — MAGNITUDE & LOCATION

A_1 = 2.0' x 2.5' = 5 FT^2 X_1 = 17'

A_2 = 5.0' x 24' = 120 FT^2 X_2 = 16.5'

A_3 = 1/2 x 12' x 24' = 144 FT^2 X_3 = 10'

A_4 = 20' x 2' = 40 FT^2 X_4 = 10'

SECTION	A (FT^2)	γ_c PCF	$W = A\gamma_c$ (LBS)	$\bar{X}$ (FT)	$W\bar{X}$ (FT-LBS)
1	5	145	725	17.0	12,325
2	120	145	17,400	16.5	287,100
3	144	145	20,880	10.0	208,800
4	40	145	5,800	10.0	58,000

$\Sigma W = W_c$ = 44805 LBS $\Sigma W\bar{X}$ = 566225 FT-LBS

$$X_c = \frac{\Sigma W\bar{X}}{\Sigma W} = \frac{566225}{44805} = 12.64 \text{ FT. TO RIGHT OF PT. Q}$$

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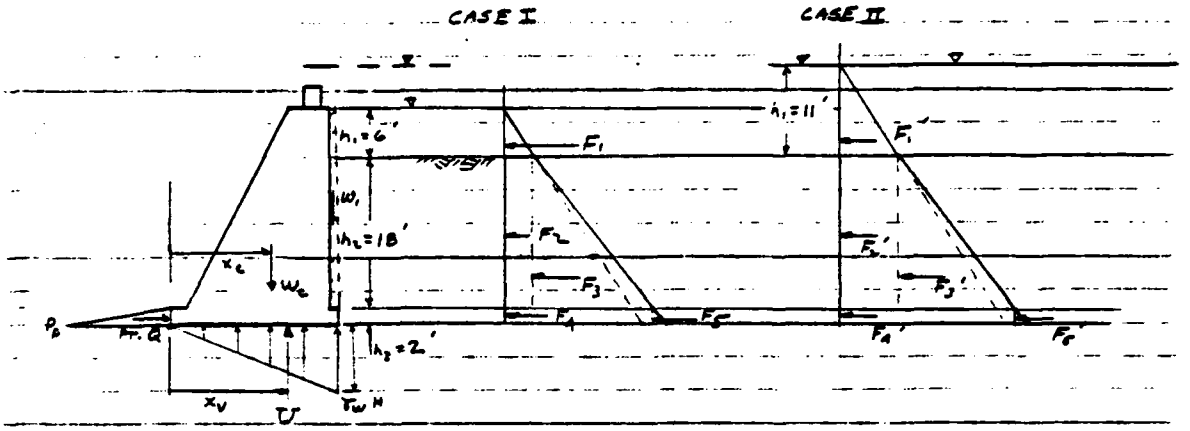

CASE I WATER SURFACE AT CREST

$P_0 = h_1 \gamma_w$

$P_1 = 6' \times 62.4 PCF = 374.4 PSF$

$P_2 = (h_1 + h_2)\gamma_w + h_2 \gamma_s' K_A$

$P_2 = (6' + 18')62.4 PCF + 18'(80 - 62.4 PCF)(0.90)$

$P_2 = 1497.6 PSF + 285.1 PSF = 1782.7 PSF$

$P_3 = (h_1 + h_2 + h_3)\gamma_w + h_2 \gamma_s' K_A + h_3 \gamma_s' K_A$

$P_3 = 26' \times 62.4 PCF + 285.1 PSF + 2'(140 - 62.4 PCF)0.172$

$P_3 = 1622.4 PSF + 285.1 PSF + 26.7 PSF = 1934.2 PSF$

$F_1 = h_1/2\ P_1 = 3' \times 374.4 PSF = 1123 \#/FT.$ OF SECTION LENGTH

$F_2 = h_2 P_1 = 18' \times 374.4 PSF = 6739 \#/FT.$

$F_3 = h_2/2\ (P_2 - P_1) = 9'(1782.7 - 374.4)_{PSF} = 12675 \#/FT.$

$F_4 = h_3 P_2 = 2' \times 1782.7 PSF = 3565 \#/FT.$

$F_5 = h_3/2\ (P_3 - P_2) = 1'(1934.2 - 1782.7)_{PSF} = 152 \#/FT.$

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CASE II WATER SURFACE 5 FT. ABOVE CREST

$P_1' = P_1 + 5_m \times 62.4 PCF = 686.4 PSF$

$P_2' = P_2 + 312 PSF = 2094.7 PSF$

$P_3' = P_3 + 312 PSF = 2246.2 PSF$

$F_1' = h_1/2 \, P_1' = 5.5_{FT.} \times 686.4 PSF = 3775$ #/FT. OF SECTION LENGTH

$F_2' = h_2 P_1' = 18_{FT.} \times 686.4 PSF = 12355$ #/FT.

$F_3' = F_3 = 12675$ #/FT.

$F_4' = h_3 P_2' = 2_{FT.} \times 2094.7 PSF = 4189$ #/FT.

$F_5' = F_5 = 152$ #/FT.

$W_1 = [h_1 \gamma_w + h_2 \gamma_s'] \times 1 FT.$

$W_1 = 6' \times 62.4 PCF + 18' \times 80 PCF = 1814$ #/FT (CASE I)

$X_1 = 20 FT - (\frac{1 FT.}{2}) = 19.5 FT.$

$W_1' = 11' \times 62.4 PCF + 18 \times 80 PCF = 2126$ #/FT (CASE II)

PASSIVE RESISTANCE FORCE

$F_p = 1/2 \gamma_s h^2 K_p$

$F_p = 1/2 (140 PCF) (2 FT)^2 (5.828)$

$F_p = 1632$ #/FT.

$Y_p = 1/3 h = 2/3 FT.$

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Made By SGM Date 5/20/80 Checked JEB Date 5/22

F.S. OVERTURNING = M_R ⇒ RIGHTING MOMENT
M_O ⇒ OVERTURNING MOMENT

$M_R = x_c W_c + Y_p F_p + x_1 W_1$

$M_R = \Sigma W\bar{x} + Y_p F_p + x_1 W_1$

$M_R = 566125^{ft\text{-}\#} + (2/3' \times 1632^{\#}) + (19.5' \times 1814^{\#})$

$M_R = 602{,}686^{ft\text{-}\#}$ (602.7 $^{ft\text{-}K}$) FOR CASE I

$M_R' = \Sigma W\bar{x} + Y_p F_p + x_1 W_1'$

$M_R' = 566.125^{ft\text{-}K} + 1088^{ft\text{-}\#} + (19.5' \times 2126^{\#})$

$M_R' = 608{,}670^{ft\text{-}\#}$ (608.7 $^{ft\text{-}K}$) FOR CASE II

$M_O = \Sigma F_Y + U x_U$

	$\bar{y}$ (FT)	F (LBS)	$F\bar{y}$ (FT-LBS)		$\bar{y}'$ (FT)	F' (LBS.)	$F'\bar{y}'$ (FT.-LBS.)
1	22	1123	24,706	1	23.67	3775	89,354
2	11	6739	74,129	2	11	12355	135,905
3	8	12675	101,400	3	8	12675	101,400
4	1	3565	3,565	4	1	4189	4189
5	2/3	152	101	5	2/3	152	101

$\Sigma F_Y = 203{,}901^{ft\text{-}\#}$ $\Sigma F_Y' = 330{,}949^{ft\text{-}\#}$

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Made By SGM Date 9/28/90 Checked EHB Date 4/24/88

$U = 1/2 \times 62.4_{PCF} \times 20' \times 26' = 16224\ ^{\#}/FT$

$U' = 1/2 \times 62.4_{PCF} \times 20' \times 31' = 19344\ ^{\#}/FT$

$x_u = 2/3 \times 20' = 40/3' \simeq 13.33$ FT.

$Ux_u = 40/3' \times 16224^{\#} = 216,320\ ^{FT-\#}$

$U'x_u = 40/3' \times 19344^{\#} = 257,920\ ^{FT-\#}$

AT 100% UPLIFT

CASE I

$FS_1 = \frac{M_R}{M_O}$

$FS_1 = \frac{602,686}{203,901 + 216,320} = 1.43$

CASE II (h = 5')

$FS_2 = \frac{M_R'}{M_O'}$

$FS_2 = \frac{608670}{330,949 + 257920} = 1.03$

Sheet 1 of 5

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Job COLONIAL DAM No. 3 Job No. 79153 H

Subject RESULTANT FORCE LOCATION

Made By SGM Date 4/28/80 Checked EHB Date 4/30/80

ANALYSIS No. 2

CASE I h = 0' (DAM CREST)

CASE II h = 5' (5 FT. ABOVE CREST)

	CASE				CASE			
	$\bar{y}$	F	F$\bar{y}$		$\bar{y}'$	F'	F'$\bar{y}'$
1	22	1123	24,706	1	23.67	3,775	89,354
2	11	6739	74,129	2	11	12,355	135,905
3	8	12675	101,400	3	8	12,675	101,400
4	1	3565	3565	4	1	4189	4,189
5	2/3	152	101	5	2/3	152	101
6	2/3	-1632	-1088	6	2/3	-1632	-1088
		ΣF	$\Sigma F\bar{y}$ =			$\Sigma F'$	$\Sigma F'\bar{y}'$

R_F = 22,622 # 202813 ft-#

R_F' = 31514 = 329861 ft-#

$Y_F = \frac{202813 \text{ ft-\#}}{22,622 \text{ \#}}$

$Y_F'' = \frac{329,861 \text{ ft-\#}}{31514 \text{ \#}}$

Y_F = 8.97 FT. ABOVE BASE

Y_F' = 10.47 FT. ABOVE BASE

Sheet 2 of 5

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Job _____ Job No. 79153 H

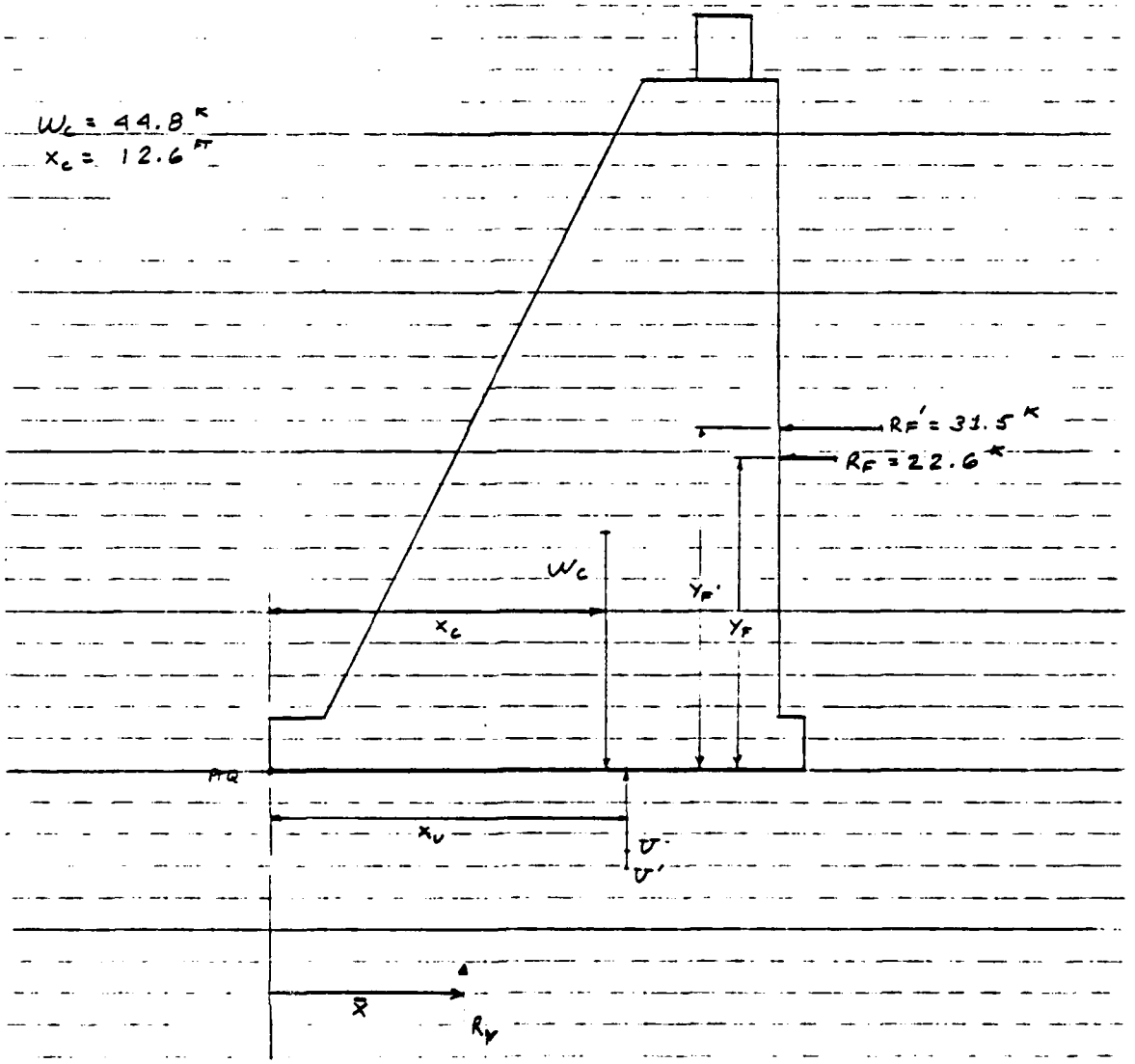
Subject _____

Made By SGM Date 4/28/80 Checked EHB Date 4/29/80

100% UPLIFT

$U = 16.32^K$ $x_u = 13.33'$

$U' = 19.34^K$



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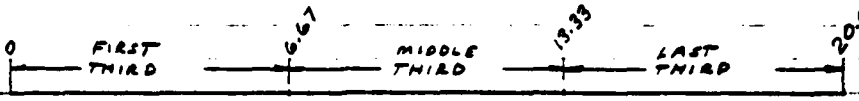
Made By SGM Date 5/20/80 Checked JEB Date 5/22



FOR F.S. = 1.0 ; $\frac{M_R}{M_O + \bar{x} R_V} = 1.0$

$M_R = M_O + \bar{x} R_V$

$\frac{M_R - M_O}{R_V} = \bar{x}$

CASE I

$\Sigma F_V = 0 \quad R_V = W_c - U + W_1$

$R_V = 44.8^K - 16.2^K + 1.8^K = 30.4^K$

$\bar{x} = \frac{602.7^{FT\text{-}K} - 420.2^{FT\text{-}K}}{30.4^K}$

$\bar{x} = 6.00$ FT.

CASE II

$\Sigma F_V = 0 \quad R_V' = W_c - U' + W_1'$

$R_V = 44.8^K - 19.3^K + 2.1^K = 27.6^K$

$\bar{x} = \frac{608.8^{FT\text{-}K} - 588.9^{FT\text{-}K}}{27.6^K}$

$\bar{x} = 0.72$ FT

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Job _____ Job No. 79153 H

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Made By SGM Date 5/20/80 Checked JEB Date 5/22

BOTH R'S ARE OUTSIDE MIDDLE THIRD OF BASE ∴

EXAMINE FOR TOE PRESSURES.

$$P = \frac{2R_V}{3\bar{x}}$$

CASE I $R_V = 30.4^K$, $\bar{x} = 6.0$ FT

$$P_{MAX_I} = \frac{2 \times 30.4^K}{3 \times 6.0^{FT}} = 3.4 \text{ KSF}$$

$$P_{MAX_I} = 3.4 \frac{K}{FT^2} \times \frac{1000^{\#}/K}{144 \text{ IN}^2/\text{FT}^2} = 23.6 \text{ PSI}$$

CASE II $R_V' = 27.6^K$, $\bar{x} = 0.72$ FT

$$P_{MAX_{II}} = \frac{2 \times 27.6^K}{3 \times 0.72^{FT}} = 25.6 \text{ KSF}$$

$$P_{MAX_{II}} = 25.6 \times \frac{1000}{144} = 177.8 \text{ PSI}$$

SDF POOL LEVEL

FOR POOL @ EL. 927.7 (SDF = 1/2 PMF)

$$V'' = \left[\frac{19344^{\#} - 16224^{\#}(3.7) + 16224^{\#}}{5}\right] / 1000^{\#}/K$$

$$V'' = 18.5^K$$

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$V''_x = 18.5^K \times 13.33^{FT}$

$V'_x = 246.6^{FT-K}$

$M_R'' = \Sigma W_x + \gamma_p F_p + x_1 \left[\left(\frac{w_1' - w_1}{5} \right) 3.7 + w_1 \right]$

$M_R'' = 567.2^{FT-K} + 19.5' \left[\left(\frac{2.1^K - 1.8^K}{5} \right) 3.7 + 1.8 \right]$

$M_R'' = 606.6^{FT-K}$

$M_o'' = \Sigma F_y + \frac{3.7}{5} \left(\Sigma F_y' - \Sigma F_y \right)$

$M_o'' = 203.9^{FT-K} + \frac{3.7}{5} \left(330.9^{FT-K} - 203.9^{FT-K} \right)$

$M_o'' = 297.9^{FT-K}$

$F.S._{SOF} = \frac{M_R''}{M_o'' + V''\bar{x}}$

$F.S._{SOF} = \frac{606.6^{FT-K}}{297.9^{FT-K} + 246.6^{FT-K}} = 1.11$

$R_V'' = W_c - V'' + W_1''$

$R_V'' = 44.8^K - 18.5^K + 2.0^K = 28.3^K$

$\bar{x}'' = \frac{M_R'' - M_o'' - V''\bar{x}}{R_V''}$

$\bar{x}'' = \frac{606.6^{FT-K} - 297.9^{FT-K} - 246.6^{FT-K}}{28.3^K} = 2.2 \text{ FT.}$

$P_{TOE} = \frac{2 R_V''}{3 \bar{x}''} = \frac{2 \times 28.3^K}{3 \times 2.2^{FT}} = 8.6 \text{ KSF} = 59.7 \text{ PSI} = 4.3 \text{ TSF}$

Sheet 1 of 5

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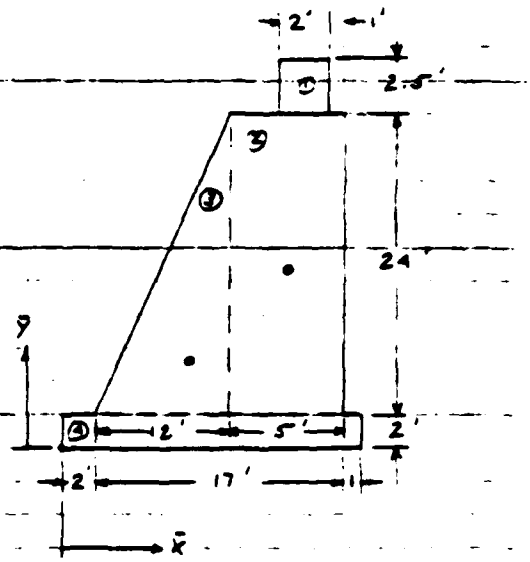
Job COLONIAL DAM No. 3 Job No. 79153H

Subject FACTOR OF SAFETY W/ EARTHQUAKE FORCE

Made By SGM Date 1/29/80 Checked ~~~ Date ~~~

SEISMIC ANALYSIS:

1) CENTROID LOCATION OF GRAVITY SECTION



$A_1 = 2.5' \times 2' = 5\ ft^2$

$A_2 = 24' \times 5' = 120\ ft^2$

$A_3 = 1/2 \times 24' \times 12' = 144\ ft^2$

$A_4 = 2' \times 20' = 40\ ft^2$

	A (ft^2)	$\bar{x}$ (ft)	$\bar{y}$ (ft)	$A\bar{x}$ (ft^3)	$A\bar{y}$ (ft^3)
1	5	18	27.25	90	136.25
2	120	16.5	14	1980	1680
3	144	10	10	1440	1440
4	40	10	1	400	40

$\Sigma A = 309\ ft^2$ $\quad \Sigma A\bar{x} = 3910\ ft^3$ $\quad \Sigma A\bar{y} = 3296.25\ ft^3$

$$\bar{x} = \frac{\Sigma A\bar{x}}{\Sigma A} = \frac{3910\ ft^3}{309\ ft^2} = 12.65\ ft$$

$$\bar{y} = \frac{\Sigma A\bar{y}}{\Sigma A} = \frac{3296.25\ ft^3}{309} = 10.67\ ft$$

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Job _____ Job No. 7953H

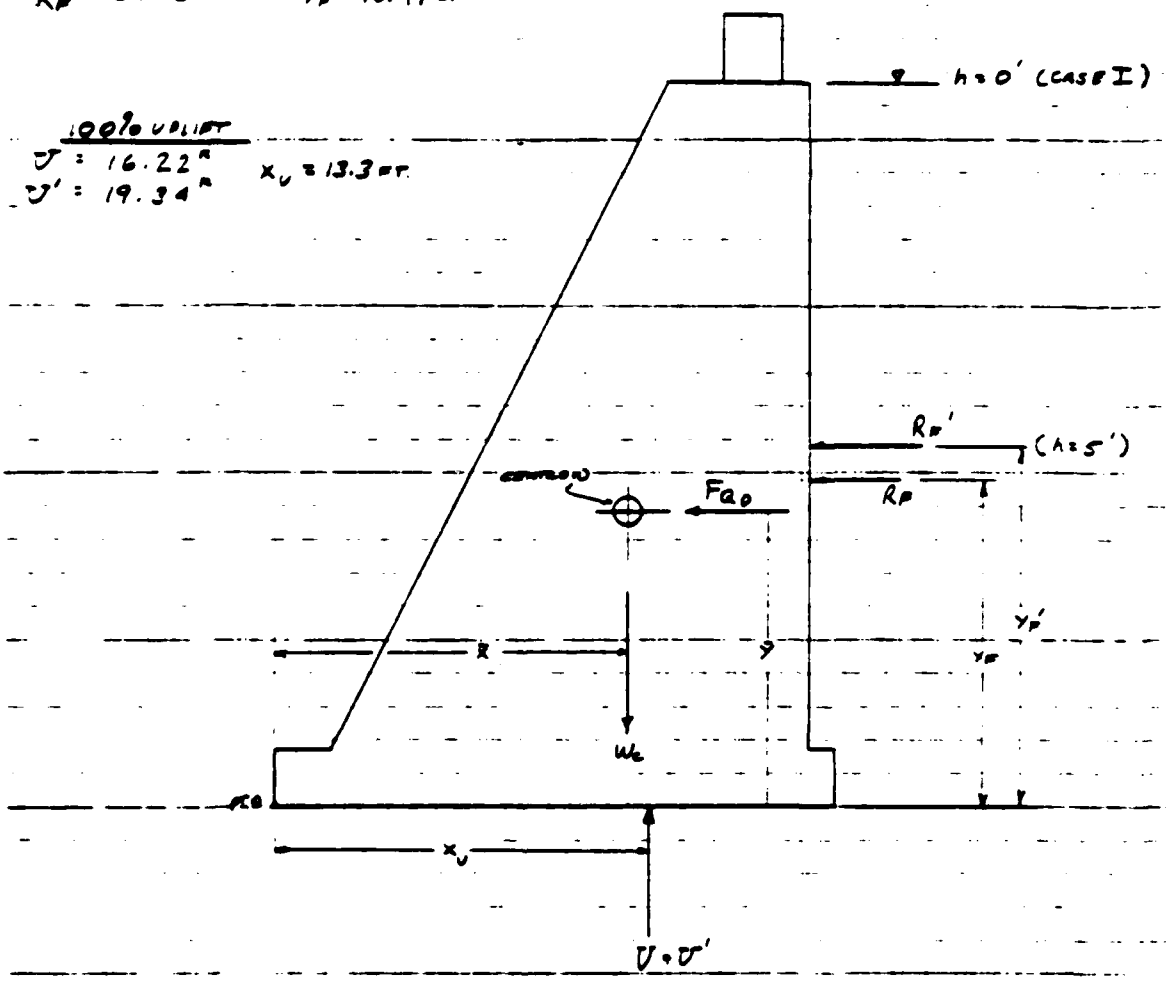
Subject _____

Made By SCM Date 9/29/00 Checked _____ Date _____

VALUES FROM "RESULTANT FORCE LOCATION"

$W_c = 44.8^K$
$R_P = 22.6^K$ $y_P = 8.97$ FT
$R_P' = 31.5^K$ $y_P' = 10.47$ FT

100% UPLIFT
$U = 16.22^K$ $x_U = 13.3$ FT.
$U' = 19.34^K$



$F_{Q_D} = 0.025\ W_c$; THE FACTOR, 0.025, IS FROM THE RECOMMENDED GUIDELINES FOR SAFETY INSPECTION OF DAMS (ZONE 1)

$F_{Q_D} = 0.025 \times 44.8^K$

$F_{Q_D} = 1.12^K$

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Job _____ Job No. 79153 H

Subject _____

Made By SGM Date 1/29/80 Checked JT Date 1/30/80

$$FS = \frac{M_R}{M_O}$$

$M_R = 602.69^{\text{I-K}}$ $M_R' = 608.77^{\text{I-K}}$

100% UPLIFT

CASE I

$$M_{O_1} = U x_U + R_F y_F + F_{a_O} \bar{y}$$

$$M_{O_1} = 16.22^{K} \times 13.33^{FT.} + 22.6^{K} \times 8.97^{FT.} + 1.12^{K} \times 10.67^{FT.}$$

$M_a = 430.89$

$$FS_1 = \frac{M_R}{M_{O_1}} = \frac{602.69}{430.89} = 1.40$$

CASE II

$$M_{O_2} = U' x_U + R_F' y_F' + F_{a_O} \bar{y}$$

$$M_{O_2} = 19.34^{K} \times 13.33^{FT.} + 31.5^{K} \times 10.47^{FT.} + 1.12^{K} \times 10.67^{FT.}$$

$M_{O_2} = 599.56^{\text{I-K}}$

$$FS_2 = \frac{M_R}{M_{O_2}} = \frac{608.77}{599.56} = 1.02$$

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Made By SGM Date 5/23/00 Checked JFB Date 5/23

SDF:

$M_R' = 606.6^{I-K}$

$M_O = M_O'' + U''x + F_{Q_0}x$

$M_O = 297.9^{I-K} + 246.6^{I-K} + (1.12^K \cdot 10.67')$

$M_O = 556.5^{I-K}$

$F.S._{SDF} = \frac{M_R''}{M_O} = \frac{606.6}{556.5} = 1.09$

TOE PRESSURES

FOR F.S. = 1.0 $\bar{x} = \frac{M_R'' - M_O}{R_V}$

CASE I: $\Sigma F_V = 0$ $R_V = W_C - U + W_1$

$R_V = 44.8^K - 16.2^K + 1.8^K = 30.4^K$

$\bar{x} = \frac{602.69^{I-K} - 430.89^{I-K}}{30.4^K} = 5.65$ FT.

R IS OUTSIDE MIDDLE THIRD (6.67' → 13.33') 0°.

$P = \frac{2R_V}{3\bar{x}} = \frac{2 \cdot 30.4^K}{3 \cdot 5.65'} = 3.6$ KSF = 25 PSI = 1.8 TSF

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CASE II :

$\Sigma F_v = 0 \quad R_v' = W_c - U' + W_1'$

$R_v' = 44.8^K - 19.3^K + 2.1^K = 27.6^K$

$\bar{x} = \frac{608.77^{FT\text{-}K} - 599.56^{FT\text{-}K}}{27.6^K} = 0.33 \text{ FT.}$

R IS OUTSIDE MIDDLE THIRD $\therefore \quad p = \frac{2R_v'}{3\bar{x}}$

$p = \frac{2 \times 27.6^K}{3 \times 0.33'} = 55.8 \text{ KSF} = 388 \text{ psi} = 27.9 \text{ TSF}$

SOF :

$\Sigma F_v = 0 \quad R_v'' = W_c - U'' + W_1''$

$R_v'' = 44.8^K - 18.5^K + 2.0^K = 28.3^K$

$\bar{x} = \frac{606.6^{FT\text{-}K} - 556.5^{FT\text{-}K}}{28.3^K} = 1.77^{FT.}$

R IS OUTSIDE MIDDLE THIRD $\therefore \quad p = \frac{2R_v''}{3\bar{x}}$

$p = \frac{2 \times 28.3^K}{3 \times 1.77'} = 10.7 \text{ KSF} = 74 \text{ psi} = 5.4 \text{ TSF}$