AD-A063 606 ARMY ENGINEERING DISTRICT NORFOLK VA F/G 13/2
NATIONAL DAM SAFETY PROGRAM. CARVIN COVE DAM (VA 02301). ROANOK--ETC(U)
JAN 78 H E STRAWSNYDER

UNCLASSIFIED NL

1 OF 1
AD A063606

END
DATE FILMED
3-79
DDC

Carvin Cove Dam (~~Inventory Number~~ VA 02301). Roanoke River Basin. Botetourt County, Virginia. Phase I Inspection Report.

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: VA 02301	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: Phase I Inspection Report National Dam Safety Program Carvin Cove Dam Botetourt County	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): U. S. Army Corps of Engineers, Norfolk District- H. E. Strawsnyder	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: U. S. Army Engineering District, Norfolk 803 Front Street Norfolk, VA 23510	12. REPORT DATE: January 1978
	13. NUMBER OF PAGES: 54
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*: Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

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

18. SUPPLEMENTARY NOTES

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

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

Dams - VA
National Dam Safety Program Phase I
Dam Safety
Dam Inspection

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

(See reverse side)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

20. Abstract

Pursuant to Public Law 92-367, Phase I Inspection Reports are prepared under guidance contained in the recommended guidelines for safety inspection of dams, published by the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general conditions of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

Based upon the field conditions at the time of the field inspection and all available engineering data, the Phase I report addresses the hydraulic, hydrologic, geologic, geotechnic, and structural aspects of the dam. The engineering techniques employed give a reasonably accurate assessment of the conditions of the dam. It should be realized that certain engineering aspects cannot be fully analyzed during a Phase I inspection. Assessment and remedial measures in the report include the requirements of additional indepth study when necessary.

Phase I reports include project information of the dam and appurtenances, all existing engineering data, operational procedures, hydraulic/hydrologic data of the watershed, dam stability, visual inspection report and an assessment including required remedial measures.

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DDC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

REVISION NO. 1 TO PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

CARVIN COVE

The cover color is revised to white. The actual cover will not be changed. Each recipient of a copy of this report should notate the existing cover. In addition, add to Section 7, the following paragraphs:

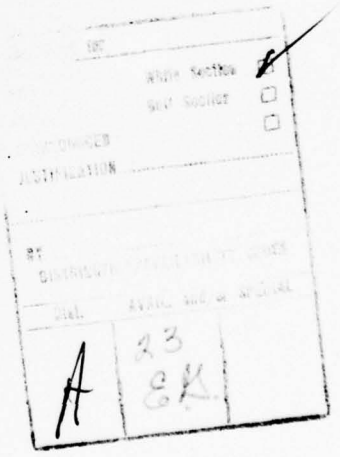
7.1.5 Using the Corps of Engineers screening criteria for initial review of spillway adequacy, it has been determined that the embankment would be overtopped for all storms exceeding approximately 11% of the PMF. The spillway is therefore, adjudged as seriously inadequate and the dam is assessed as unsafe, non-emergency.

The classification of "unsafe" applied to a dam because of a seriously inadequate spillway is not meant to connote the same degree of emergency as would be associated with an "unsafe" classification applied for a structural deficiency. It does mean, however, that based on an initial screening, and preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard to loss of life downstream from the dam.

7.2.3 In accordance with paragraph 7.1.5, it is recommended that within two months from the date of notification to the Governor of the Commonwealth of Virginia, the owner engage the services of a professional consultant to determine by more sophisticated methods and procedures the adequacy of the spillway. Even though the seriously inadequate spillway would produce a dam failure primarily from hydrologic reasons, remedial measures in structural or geotechnical areas may be needed to remove the dam from an unsafe classification. Within 3 months of the date of notification to the governor, the professional consultant's report of appropriate remedial mitigating measures should have been completed and the owner should have an agreement with the Commonwealth of Virginia to a reasonable time frame in which all remedial measures will be complete. In the interim, a detailed emergency operation plan and warning system should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

CARVIN COVE DAM

TABLE OF CONTENTS



PHASE 1 REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Carvin Cove
State: Virginia
County: Botetourt
Coordinates: Lat. 37° 22.2' Long. 79° 57.5'
Stream: Carvin Creek, tributary of Roanoke River
Date of Inspection: 27 - 28 December 1977

The 85 foot high Carvin Cove Dam is a cyclopean masonry, gravity structure located in a narrow V-shaped gap above residential developments in Botetourt County and the City of Roanoke, Virginia. Design calculations were not available for review and their existance in the City of Roanoke archive files was unknown. A Geology report and a pictorial record of construction were available and reviewed. The field observation indicated several seepage areas on the downstream face of the dam near the left side of the spillway and in the vicinity of the wet wells housing valves for the raw water transmission line. A small ground seep was observed at the left abutment-masonry interface, and several seep areas were observed on the right abutment about 50 feet downstream of the dam. Seepage, if any, at the spillway-foundation interface could not be determined because of the 1-2 inches of water flowing over the spillway. Hydraulic Analysis estimates indicate that the spillway is capable of passing the 100 year flood with a pool level at the top of the dam (no freeboard). Stability calculations on the tallest dam section for loading from the 100 year storm show the resultant within the kern of the base and a factor of safety against sliding of 4.9. Standard Project and Probable Maximum Flood routings indicate water flowing over the top of the dam at depths of about 4 and 10 feet, respectively. This condition requires immediate priority to establish a warning system and to study measures of reducing the overtopping potential. Overtopping is critical in that rock jointing is such that the abutment may be eroded. Stability analysis indicates the resultant force is outside the kern of the concrete section. The overtopping potential was verbally reported to the City of Roanoke Department of Utilities and the Virginia State Water Control Board.

APPROVED:

Ronald H. Routh

RONALD H. ROUTH
LTC, Corps of Engineers
Acting District Engineer

SECTION 1. PROJECT INFORMATION

1.1 General

1.1.1 Authority: Public Law 92-367, 8 Aug 72 authorized the Secretary of the Army, through the Corps of Engineers to initiate a national program of safety inspections of dams throughout the United States. The Norfolk District has been assigned the responsibility of supervising the inspection of dams in the Commonwealth of Virginia.

1.1.2 Purpose of Inspection: The purpose of the Phase I inspections is to identify expeditiously those dams which may be a potential hazard to human life or property.

1.2 Project Description

1.2.1 Dam and Appurtenances: Carvin Cove Dam is an 85 foot high, cyclopean masonry, gravity structure with a 114 foot overflow "Ogee" like spillway. The length of the dam crest is 315 feet and the width is 17 feet. The regional and vicinity maps are shown on plates 1 and 2. The plan-profile, typical cross sections and details of the dam are shown on plates 3 through 7. Appurtenances include a 48 inch raw water discharge at elevation 1115, an 18 inch blow off pipe at elevation 1110 and twin 12 inch drains with an upstream invert elevation of 1097. The raw water discharge line is equipped with a valved 18" blow off downstream of the dam. Details of the wet wells and valve arrangements are shown on plates 6 and 7, Appendix C.

1.2.2 Location: Carvin Cove is located on Carvin Creek in Botetourt County just north of its border with the City of Roanoke.

1.2.3 Size Classification: The dam classifies as "Intermediate" size based on both storage capacity and height.

1.2.4 Hazard Classification: The Carvin Cove Project, because of its location upstream of residential and commercial development must be given a "High" classification.

1.2.5 Ownership: City of Roanoke, Virginia.

1.2.6 Purpose of Dam: Water supply and non body water contact recreation.

1.2.7 Design and Construction History: Carvin Cove was designed by Sanburn and Bogert, Consulting Engineers, New York City for the Richmond Development Corporation, the holding company for the Roanoke Water Works Company which was the predecessor of the current Department of Utilities. Geologic Investigations were performed by

Professor Charles P. Berkey in 1924. A copy of his report is attached as Appendix B. Construction was accomplished in 1927 by W. W. Boxley and Company. The City of Roanoke Department of Utilities modified the dam in 1946 and filled the reservoir for the first time in 1947. The modifications consisted of a concrete protective covering over the 48 inch and 18 inch pipes and installation of double valves on the 12-inch drains at the base of the dam. The present consultant for the City Department of Utilities is the firm of Alvord, Burdick and Howson, Chicago, Ill.

1.2.8 Normal Operating Procedures: The normal procedure is to operate the Carvin Cove project at a pool near elevation 1170, the top of the ungated spillway. The city drains 9 to 12 MGD for water supply. When inflow from Carvin Creek is insufficient to maintain the a normal pool near elevation 1170, flows from nearby Tinker and Catawba Creeks are diverted to Carvin Cove through gated tunnels. These diversion tunnels are controlled to provide only those flows necessary to maintain the reservoir near the normal level. Instrumentation is limited to that necessary for monitoring the pool level and the raw water withdrawn. The recording devices provide a daily record; however, they are read weekly. At the time of their weekly reading, City employees normally give the dam a cursory visual observation. The Department of Utilities performs weekly inspections to check the workability of the valves. The current consulting firm performs inspections on all three City Water Supply Dams about every 5 years and this includes underwater observation by divers of the upstream face of the Carvin Cove dam.

1.3 Pertinent Data

1.3.1 Drainage Area: 17.9 square miles above dam.

1.3.2 Discharge at Damsite:

1.3.2.1	Maximum known flood at damsite	1000 cfs 1/
1.3.2.2	Warm water outlet at pool elevation	Not Applicable (N/A)
1.3.2.3	Diversion tunnel low pool outlet at pool elevation	N/A
1.3.2.4	Diversion tunnel outlet at pool elevation	N/A
1.3.2.5	Gated spillway capacity at pool elevation	N/A
1.3.2.6	Gated spillway capacity at maximum pool elevation	N/A

1.3.2.7	Ungated spillway capacity at maximum pool elevation	4400 CFS
1.3.2.8	Total spillway capacity at maximum pool elevation	4400 CFS
1.3.3	Elevation (ft. above MSL)	
1.3.3.1	Top Dam	1175
1.3.3.2	Maximum pool design surcharge	1175
1.3.3.3	Full flood control pool	N/A
1.3.3.4	Recreation pool	N/A
1.3.3.5	Spillway crest (ungated)	1170
1.3.3.6	Upstream portal invert diversion tunnel	N/A
1.3.3.7	Downstream portal invert diversion tunnel	N/A
1.3.3.8	Streambed at centerline of dam	1090
1.3.3.9	Maximum tailwater	estimated to be 1097 during 100 year flood
1.3.4	Reservoir	
1.3.4.1	Length of maximum pool	5 miles
1.3.4.2	Length of recreation pool	N/A
1.3.4.3	Length of flood control pool	N/A
1.3.5	Storage (acre-feet)	
1.3.5.1	Recreation pool	N/A
1.3.5.2	Flood control pool	N/A
1.3.5.3	Design surcharge	3200
1.3.5.4	Top of dam	23,000

1.3.6	Reservoir Surface (acres)	
1.3.6.1	Top dam	unknown
1.3.6.2	Maximum pool	unknown
1.3.6.3	Flood-control pool	N/A
1.3.6.4	Recreation pool	N/A
1.3.6.5	Spillway crest	640
1.3.7	Dam	
1.3.7.1	Type	Cyclopean Masonry (Gravity)
1.3.7.2	Length	315 feet
1.3.7.3	Height	85 feet
1.3.7.4	Top Width	17 feet
1.3.7.5	Side Slopes	Varies-See plates 4 & 5
1.3.7.6	Zoning	N/A
1.3.7.7	Impervious Core	N/A
1.3.7.8	Cutoff	N/A
1.3.7.9	Grout curtain	footnote 2/
1.3.8	Diversion and Regulating Tunnel	None
1.3.9	Spillway	
1.3.9.1	Type	Concrete, ungated "Ogee" like
1.3.9.2	Length of weir	114'
1.3.9.3	Crest elevation	1170
1.3.9.4	Gates	None
1.3.9.5	U/S Channel	N/A
1.3.9.6	D/S Channel	Concrete apron at base of spillway

1.3.10 Regulating Outlets:

1.3.10.1 Valved 18 inch diameter blow off with invert elevation at 1110 MSL

1.3.10.2 Valved, twin, 12 inch diameter outlets with upstream invert elevations at 1097 MSL. These outlets were used for stream diversion during construction.

1.3.10.3 A 48 inch diameter raw water discharge with an invert elevation at 1115 MSL. This line necks down to 36 inch diameter enroute to the filtration plant and an 18 inch diameter gated blow off discharging into the creek is provided approximately 3,000 feet downstream of the dam

1.3.10.4 The above regulating outlets provide the only means to dewater the reservoir. It is estimated that 60 days would be required if total dewatering were necessary during a period of average inflow.

1.3.11 Footnotes

1/ Estimate based on information from City Department of Utilities personnel that maximum known flood was Hurricane Agnes in June 72 when 2 feet of water was passing over spillway (approximately 1,000 cfs).

2/ Grouting was provided for in the Contract Documents if necessary, however, records did not indicate that grouting was performed. A later telephone conversation with one of the construction workers living in Clifton Forge, Virginia, indicated that some grouting had been performed on the right abutment by drilling and placing grout into the abutment. The amount of take, grout pressures, and exact locations were not reported.

SECTION 2: ENGINEERING DATA

2.1 Design: There is no record of any design studies or computations for Carvin Cove Dam, except for the attached Geologist report

2.2 Construction: Construction records were available at the Department of Utilities in the form of photographs. Almost daily progress was recorded in picture form. Several photo albums are on file. The telephone conversation with the construction worker living in Clifton Forge, Virginia, generally confirmed the construction activity recorded on film.

2.3 Operation: Current operation procedures are generally limited to those necessary for control of water supply which is the main purpose of the project. These operational functions consisting of the Tinker and Catawba Creek supply tunnels, operation and maintenance on the sluice valves, and weekly inspections are adequately performed by the personnel of the Department of Utilities.

2.4 Evaluation: The Roanoke City Department of Utilities has maintained, as well as possible, a complete file of engineering and construction records. The files include the original deed to the land and contain all modifications made to the dam to date. The only data which is missing is the original design studies and computations, if any, other than the geologists report were made. Existing operational procedures are understood and performed by the Utilities Department personnel.

SECTION 3. VISUAL INSPECTION

3.1 Findings: Information observed in the field is attached and marked Appendix A. These include the tape transcription of observations by Messrs. Irving and Anderson, a written report by the geologist, Mr. Cavan, and photographs.

3.2 Evaluation: The visual inspection revealed 5 or 6 through seepage points which occur through the face of the dam approximately 17 feet below elevation 1175. These are located directly in front of the valve pit house, on the downstream face. A rather large seep also occurs in the valve pit nearest the spillway at approximately the same elevation as the seeps on the face of the dam. This is a good indication a plane of seepage exists about 17 feet below the top of the dam underneath the valve pit house. Nothing was observed in the field that required immediate remedial action. Later hydraulic and stability calculations indicated that overtopping was critical. The relatively small amount of surface flaking which has occurred on the face of the dam over the last 50 years indicates the dam has good weathering capabilities. The only remedial surface treatment done to the dam is a grout coat applied to the top and extending 5 feet down either face of the dam. The horizontal cracking on the face of the dam appears to occur along the concrete lift lines. Over a 50 year life cycle, this is not an uncommon occurance. There is no evidence to indicate the cracks are other than facial. These cracks will promote accelerated weathering of the dam. In addition to the ground seeps observed on the right abutment a wet spot was noted at the dam's left abutment interface at approximately elevation 1167±. No material was observed piping from the wet spot, and in fact flowing water was not observed. All presently observed seeps in the abutments are considered minor in nature, however, they should be observed during weekly inspections to prevent a worsening condition going unobserved.

3.3 Attendees:

Mr. Kit Kaiser (part time)	Roanoke Department of Utilities
Mr. Craig Sluss	Roanoke Department of Utilities
Mr. Robert Garst (part time)	Roanoke Department of Utilities
Mr. Robert Gay	Virginia State Water Control Board
Mr. Donald Criger (part time)	Virginia State Water Control Board
Mr. Charles Boon (part time)	Virginia State Water Control Board
Mr. Will Estes (part time)	Virginia State Water Control Board
Mr. Larry Holland	Norfolk District, Corps of Engineers
Mr. Bruce Cavan	Norfolk District, Corps of Engineers
Mr. Jeffrey Irving	Norfolk District, Corps of Engineers
Mr. Carl Anderson	Norfolk District, Corps of Engineers

SECTION 4. OPERATIONAL PROCEDURES:

4.1 Procedures: Existing normal operating procedures require the pool to be maintained at or near the spillway elevation of 1170. During dry periods, the Tinker and Catawba Creek supply tunnels are utilized to provide additional inflow. These supply tunnels are regulated to provide inflow to Carvin Cove Reservoir and still maintain agreed upon flows in the creeks downstream from the intakes. With the reservoir full, these supply tunnels are closed. All sluice valves are checked and operated (by hand) once weekly to insure their operability. Also, a cursory inspection of the dam is provided during these weekly inspections. On five year intervals, Department of Utilities consulting firm, Alvord, Burdick and Howson, Chicago, Ill. along with a diving firm, provide a complete inspection of the dam including the upstream face and the wet wells.

4.2 Maintenance of Dam: Routine maintenance of the dam is generally not required due to the type of structure. In 1972, after a full inspection, the crest of the dam and portions of the up and downstream faces on the left side were gunited.

4.3 Maintenance of Operating Facilities: The outflow pipes and valves are maintained by the Department of Utilities personnel. All valves are checked weekly to insure their operability.

4.4 Warning Systems: At the present time there are no warning systems or evacuation plans in operation.

4.5 Evaluation: Maintenance and inspection of the dam by Department of Utilities personnel and the scheduled major inspection are considered acceptable.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Design Data: Design Data concerning the hydraulic/hydrologic considerations was not available for review.

5.2 Experience Data: Personnel of the Department of Utilities indicated that the maximum known flood at Carvin Cove was two feet over the spillway during Hurricane Agnes in June 1972. This level is estimated to be about the 25-year event. The tailwater elevation during this storm was not measured, however, it was estimated to be a few feet above the spillway apron by the Department of Utilities personnel.

5.3 Visual Observations and Findings:

5.3.1 The Carvin Cove Reservoir is a water supply impoundment contained by a cyclopean masonry gravity dam. The drainage area above the dam is approximately 18 square miles. Because the dam is of intermediate size and its location dictates a high hazard potential, the probable maximum flood is appropriate for the hydrologic evaluation.

5.3.2 The top of the dam is at elevation 1175 M.S.L. and the crest of the ungated spillway, located in the middle of the dam, is elevation 1170 M.S.L. There is a 48-inch diameter raw water discharge line with a dam centerline (DCL) invert elevation of 1115 M.S.L. This line necks down to 36-inch diameter enroute to the downstream filtration plant. A valved 18-inch diameter blowoff is attached to the 48-inch outfall approximately 3,000 feet downstream of the dam. Additional outlets capable of regulating the reservoir pool level include a valved 18-inch diameter blowoff with a DCL invert elevation of 1110 M.S.L. and two valved 12-inch diameter blowoffs at the base of the dam with upstream invert elevations of 1097 M.S.L.

5.3.3 The ungated emergency spillway approximates ogee configuration. The spillway crest is horizontal, with a length of 114 feet, and is bounded on each side by the sharp-edged crest sections. With the reservoir pool at the top of the dam, the spillway is estimated to have discharge capacity of 4400 CFS.

5.3.4 With the reservoir pool at the spillway crest, the surface area is 640 acres and the storage is estimated to be 19,800 acre-feet. A storage of approximately 23,000 acre-feet is available with the reservoir pool at the top of the dam. This provides at least 3,200 acre-feet or 3.3 watershed inches of surcharge storage prior to overtopping the dam. The length of the reservoir at the top of the

dam is approximately 5 miles. The reservoir pool level is monitored daily and the weekly readings are recorded. The withdrawal rate for water supply averages 9-12 MGD (15-20 CFS). Floods of record include Tropical Storm Agnes in June 1972 and heavy rains in April 1977 during which spillway discharge depths reached 2.0 and 1.5 feet, respectively. No damage was reported downstream of the dam during either flood.

5.3.5 Maintaining a steady 0.3% stream bed slope, Carvin Creek flows through 12 bridges or culverts before intersecting Tinker Creek approximately 6 miles downstream of the dam. There are approximately 15 to 20 residences between Carvin Cove Dam and the first bridge approximately 3,500 feet downstream. Additional downstream details are available in a Wilmington District Flood Plain Information Report for Tinker and Carvin Creeks - October, 1970. The complete report is not appended, however, selected cross sections and flood profiles are included in Appendix E. The aforementioned first bridge downstream of the dam is located approximately 5.38 miles above the confluence of Tinker and Carvin Creeks (250 feet upstream of the Interstate 81 double culvert) and is not shown on the flood profiles.

5.4 Overtopping Potential:

5.4.1 General: Assuming an initial pool level at the crest of the spillway, elevation 1170, the Standard Project Flood (SPF) and the Probable Maximum Flood (PMF) were routed through the spillway and over the dam. Table 1 summarizes the information obtained.

5.4.2 Carvin Cove Dam exhibits a relatively high potential for being overtopped. Evaluated against the Probable Maximum Flood, the spillway capacity is severely inadequate. The spillway and associated surcharge storage are probably adequate to prevent dam overtopping by floods less severe than the 1 Percent Exceedence Frequency Flood. If there were no permanent structures for human habitation downstream of the dam, the 1 Percent Flood might be appropriate for spillway evaluation; however, the Wilmington District's Report indicates 80 structures within Carvin Creek's Intermediate Regional Flood Plain alone, consisting primarily of single unit family housing. Approximately 10 to 20 of these houses are between Carvin Cove Dam and the first bridge downstream.

TABLE 1

FLOOD	SPF 1/	PMF 2/
Reservoir:		
Peak Inflow (CFS)	25,500	58,000
Peak Elevation (FT.MSL)	1179	1185
Dam:		
Overtop Depth (ft)	4	10
Dam & Spillway:		
Peak Outflow (CFS)	15,000	40,000
Spillway:		
Discharge Capacity Required to Prevent Dam Overtop (CFS)	19,000	51,000

1/ The Standard Project Flood is an estimate of flood discharges that may be expected from the most severe combination of meteorologic and hydrologic conditions that are considered reasonably characteristic of the geographical region involved, excluding extremely rare combinations.

2/ The Probable Maximum Flood is an estimate of flood discharges that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

SECTION 6. STRUCTURAL STABILITY

6.1 Evaluation of structural stability: In the absence of original structural design computations, a stability check has been performed on a full cross-section through the dam (see Appendix C). The stability computations are based on Gravity Dam Design, U. S. Army Corps of Engineers Manual EM 1110-2-2200, 25 Sep 58 (including Change 2) and ETL 1110-2-63. The stability of the dam is within the criteria outlined in the manual for heights of water up to elevation 1175 (top of the dam). This height is produced by the 100 year flood and is the point at which overtopping begins to occur. A height of water above this level produces conditions which put the dam in a potential failure classification and, therefore, a hazard to the downstream flood plain environment.

The dam meets the stability criteria for the 100 year storm. The results of the stability analysis for the loading condition of the PMF show 42% of the base in compression and a factor of safety against sliding of 4.04.

The percent of base in compression for the loading condition of the PMF is considerably below the 100% required. However, the dam under conditions of the PMF loading is not in eminent danger of failure.

The stability calculations performed were of a preliminary nature and quite conservative. The dam is a completely monolithic structure with sections of lesser height than the one analyzed. Stability computations based on the total structure would indicate better stability characteristics than the single identical section analyzed.

Further computations are outside the scope of a Phase I Report.

SECTION 7. ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

7.1 Assessment:

7.1.1 Safety: The Carvin Cove project, as observed in Dec 1977 appears to be adequate with the exception of its inability to pass any flood exceeding the 100 year event without overtopping.

7.1.2 Adequacy of Information: Original design calculations, except for the geologist's report were not available. The later modifications and remedial treatment by the Department of Utilities are well documented and were adequate.

7.1.3 Urgency: Immediate attention needs to be directed to the through seepage plane encountered beneath the valve house at approximate elevation 1163 and to the overtopping potential for storms in excess of the 100 year event.

7.1.4 Necessity for Phase II: A Phase II inspection is not considered necessary.

7.2 Recommendation/Remedial Measures:

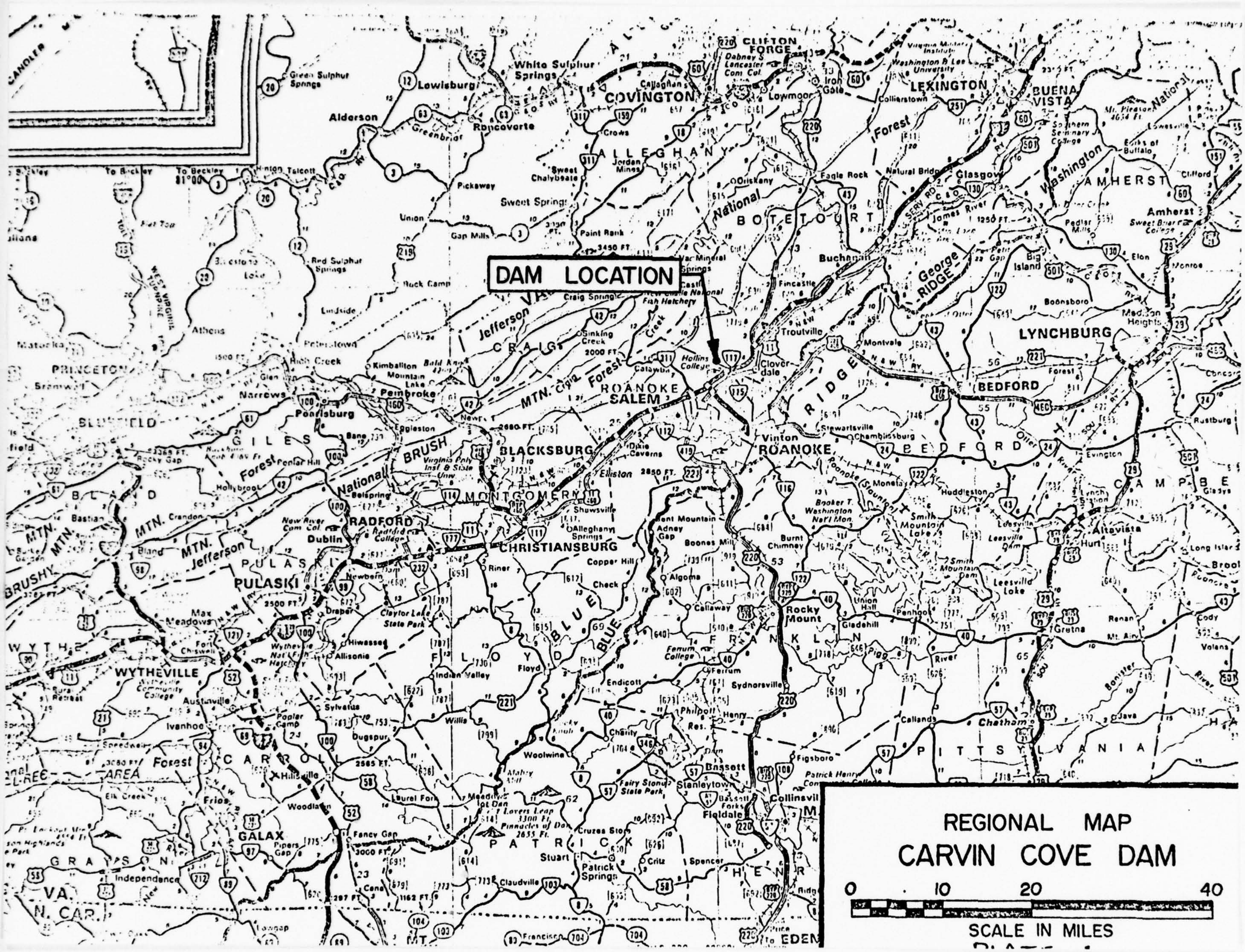
7.2.1 Immediate Remedial Measures:

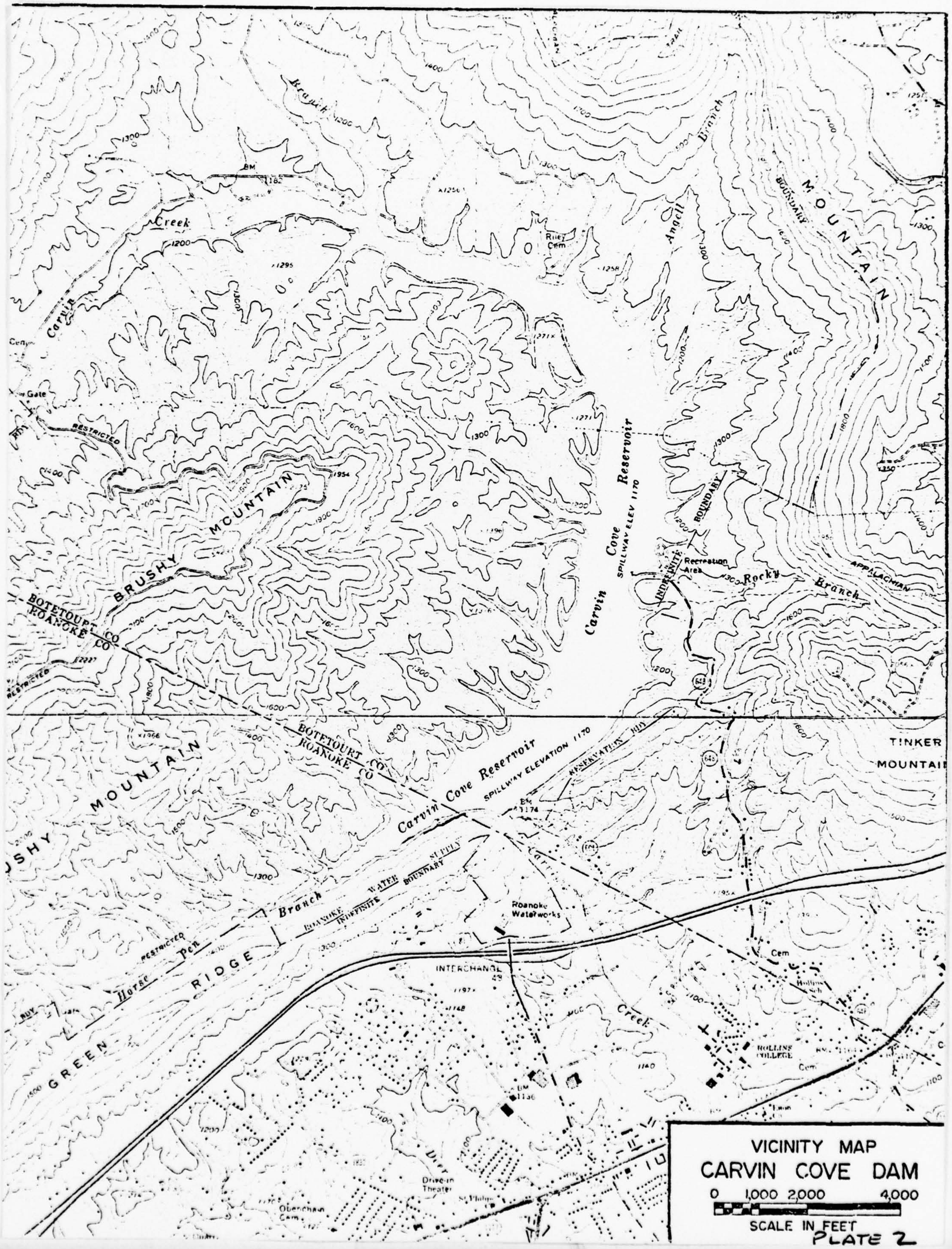
7.2.1.1 Through Seepage Plane: Remedial treatments necessary to eliminate the through seepage plane under the valve pit house should be undertaken immediately by the Department of Utilities.

7.2.1.2 Ground Seeps: Immediately set up and maintain a regular observation schedule of inspecting the ground seeps to prevent a worsening condition going unobserved.

7.2.1.3 Provide for a highly reliable flood warning system for the Carvin Creek basin downstream of the dam, recognizing that this method will not prevent loss of property but may avoid loss of life and provide around-the-clock surveillance during periods of high runoff until corrective actions are accomplished.

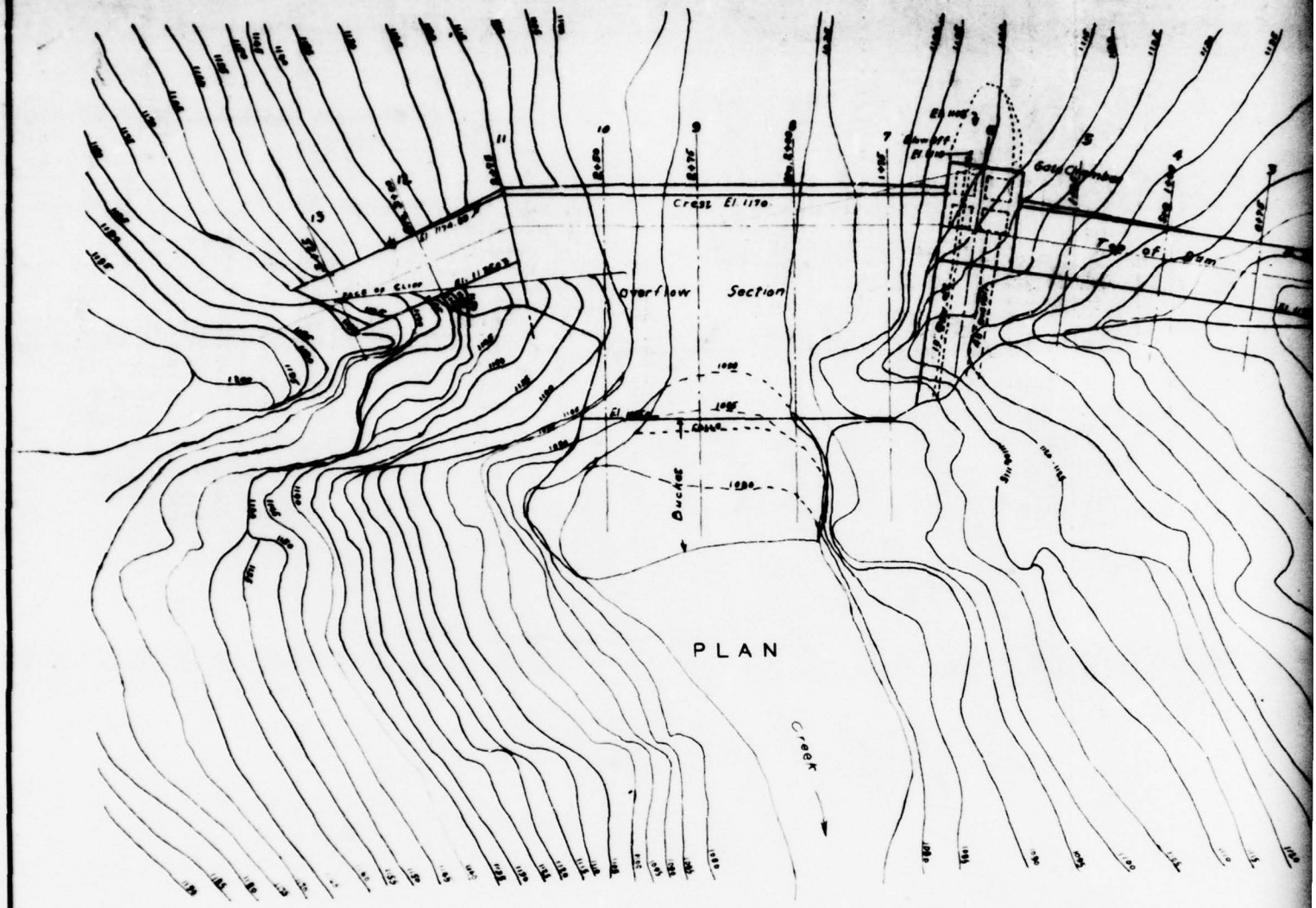
7.2.2 Other Recommendations: The conservative analysis included in this report cannot accurately determine if remedial measures are necessary to improve structural stability, but strongly indicate that further more rigorous analysis is required. It is recommended that the owner of the dam immediately undertake an engineering study to determine remedial treatments to reduce the overtopping potential threatening the stability of the dam and the integrity of the abutments.

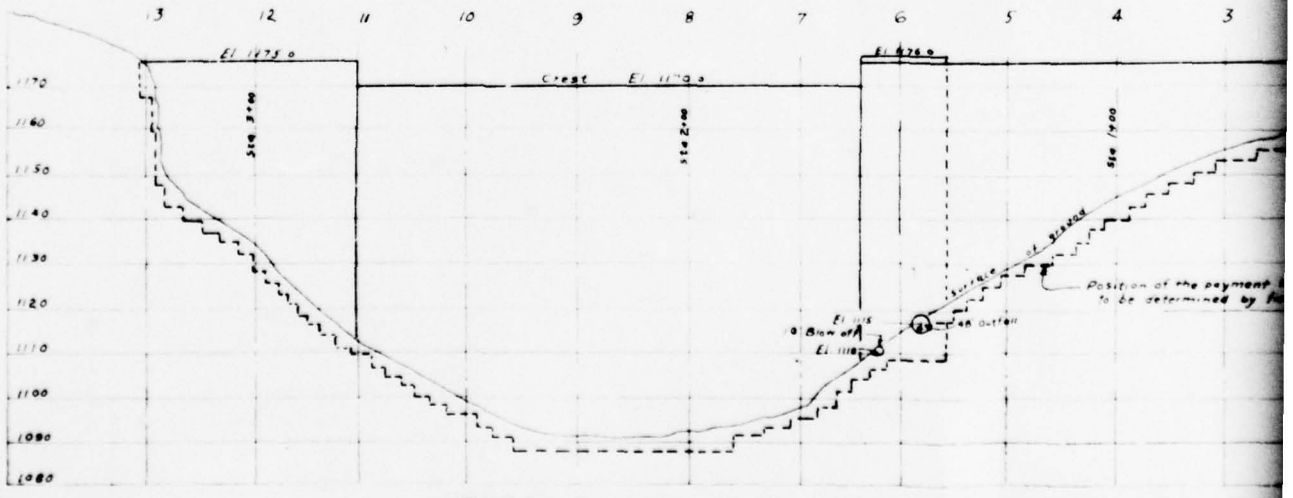

DAM LOCATION
REGIONAL MAP
CARVIN COVE DAM
0 10 20 40
SCALE IN MILES
CLIFTON FORGE
COVINGTON
LEXINGTON
BUENA VISTA
LYNCHBURG
BEDFORD
ROANOKE
SALEM
BLACKSBURG
CHRISTIANSBURG
RADFORD
PULASKI
WYTHEVILLE
GALAX
BLUEFIELD
PRINCETON
ALLEGHANY
BOTETOURT
CRAIG
GILES
MONTGOMERY
FLOYD
FRANKLIN
BEDFORD
CAMPBELL
PITTSYLVANIA
PATRICK
HENRY
CARROLL
GRAYSON
AMHERST
Rocky Mount
Vinton
Troutville
Cloverdale
Hollins College
Buchanan
Fincastle
Narrows
Pearisburg
Pembroke
Dublin
Floyd
Stuart
Bassett
Collinsville
Chatham
Altavista
Gretna
VA.
N. CAR.



VICINITY MAP
CARVIN COVE DAM

PLATE 2

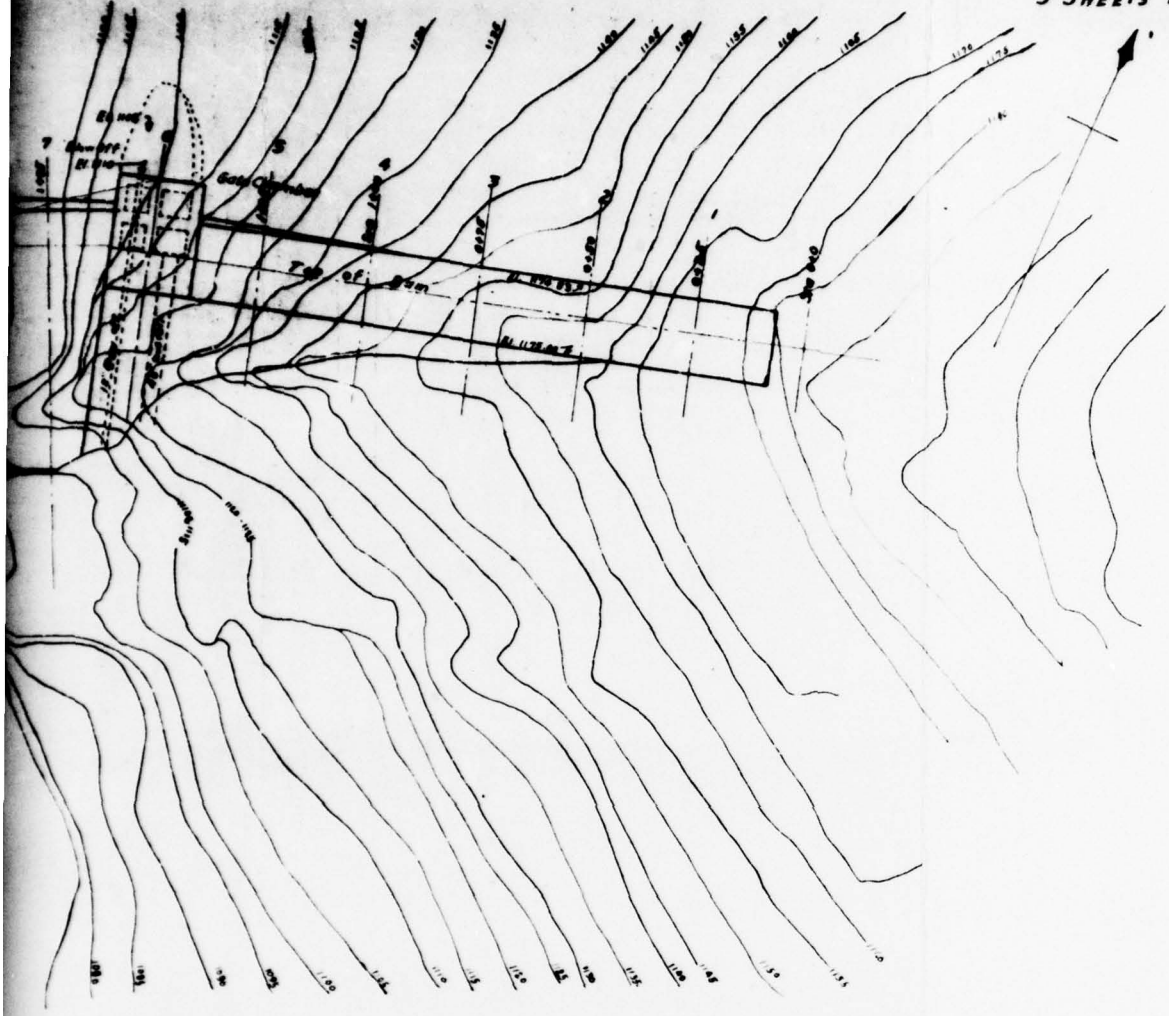


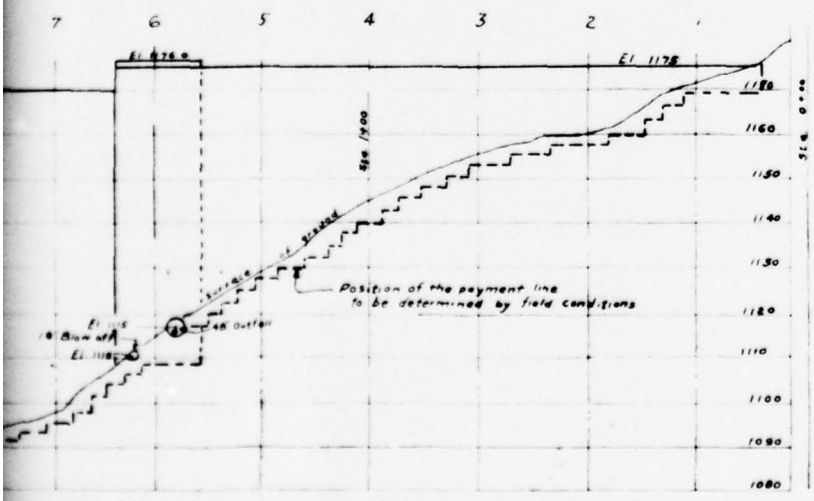


PROFILE OF DAM ON CENTER LINE

CONTRACT C SHEET 1

5 SHEETS IN SET





M ON CENTER LINE

ROANOKE VA.

RIHMOND DEVELOPMENT CORPORATION

CARVINS COVE DAM

GENERAL PLAN

Scale 1" = 20'

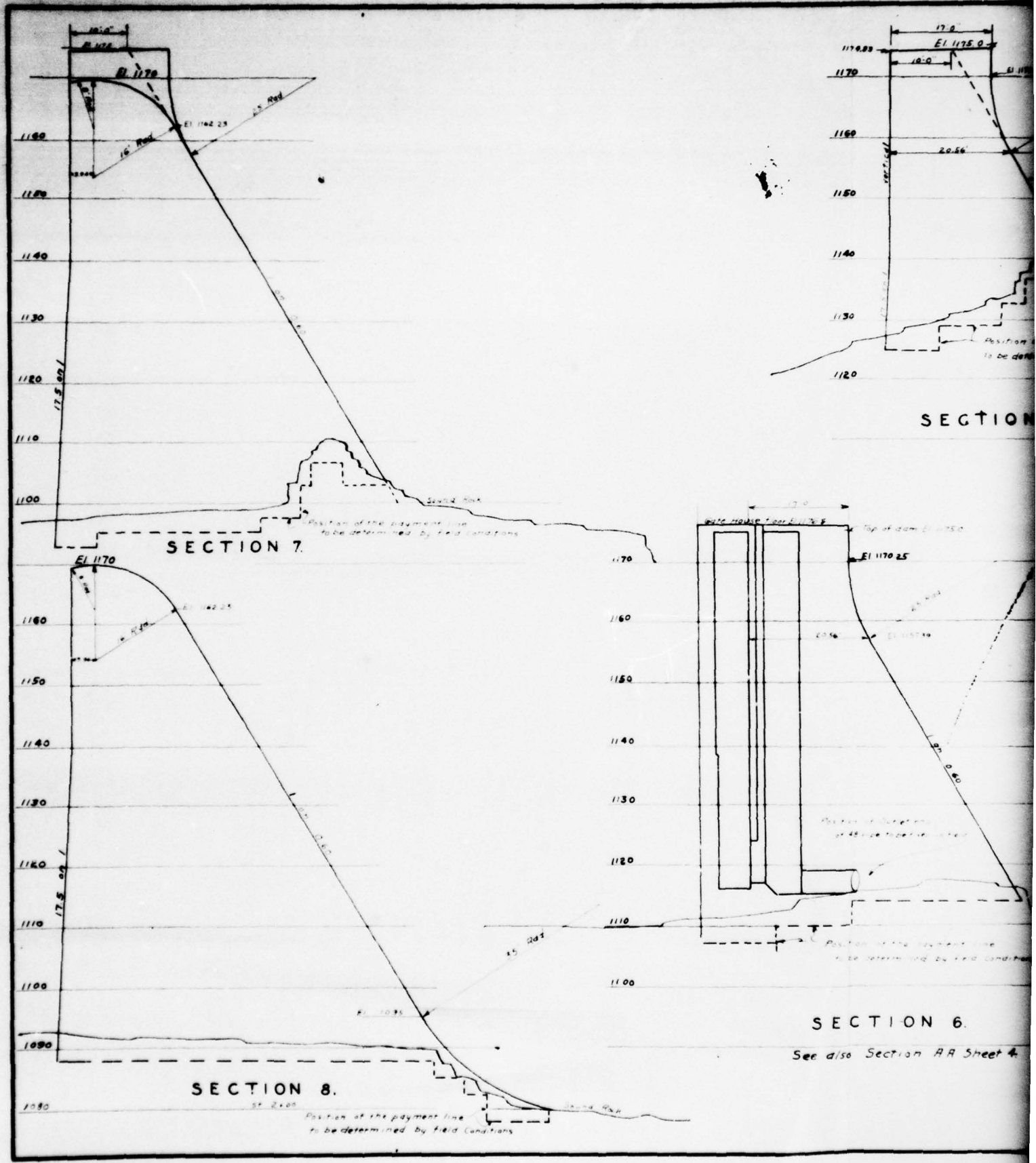
Sanborn & Bogert
Consulting Engineers
New York City

Oct 1926
F3 - D4
376-1

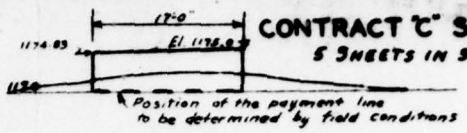
Traced By E.L.A. March 30, 1976

2

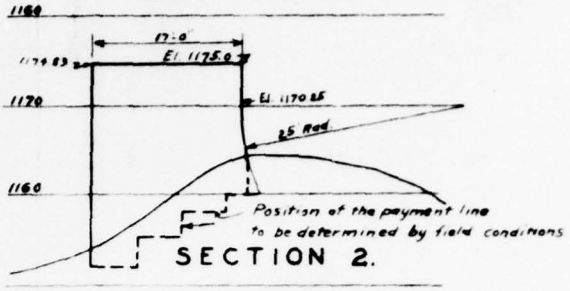
PLATE 3


El 1170
El 1162.25
1160
1150
1140
1130
1120
1110
1100
SECTION 7.
Position of the payment line to be determined by field conditions
El 1170
1160
1150
1140
1130
1120
1110
1100
1090
SECTION 8.
Position of the payment line to be determined by field conditions
El 1170.25
1170
1160
1150
1140
1130
1120
1110
1100
SECTION 6.
See also Section AA Sheet 4.
El 1175.0
1170
1160
1150
1140
1130
1120
SECTION

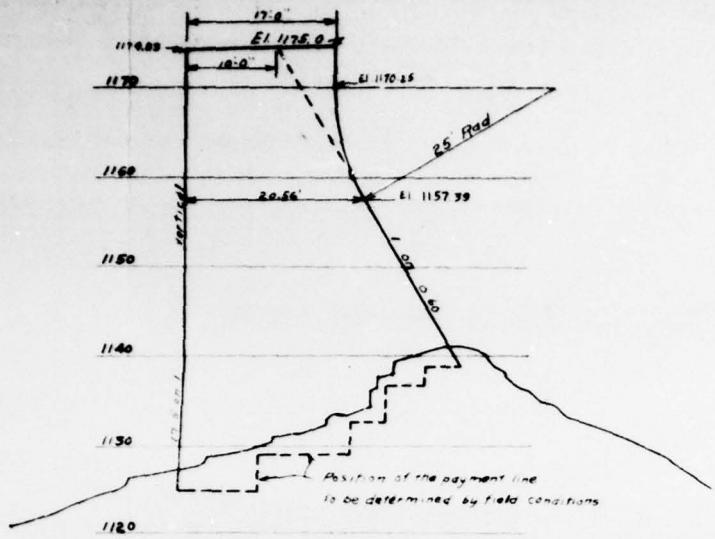
CONTRACT "C" SHEET 2.
5 SHEETS IN SET



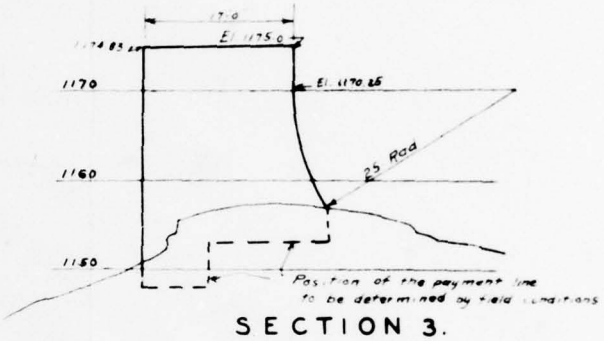
SECTION 1.



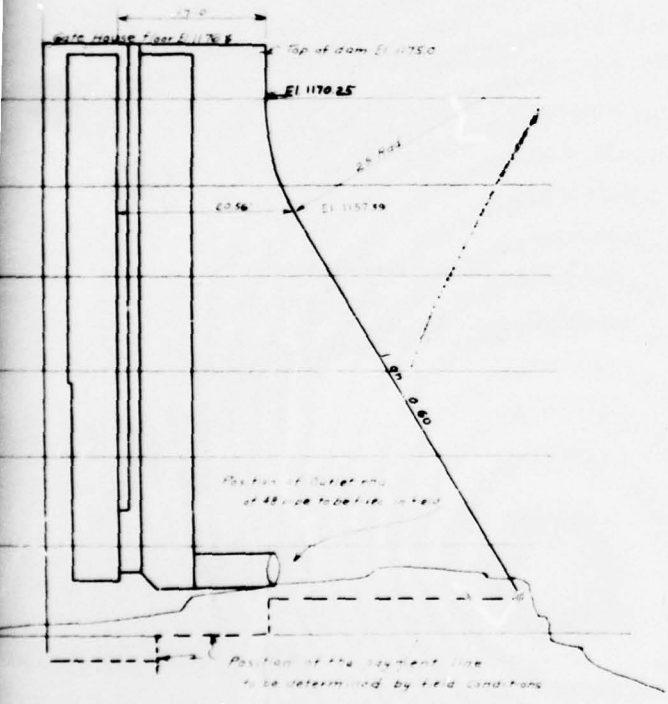
SECTION 2.



SECTION 5.

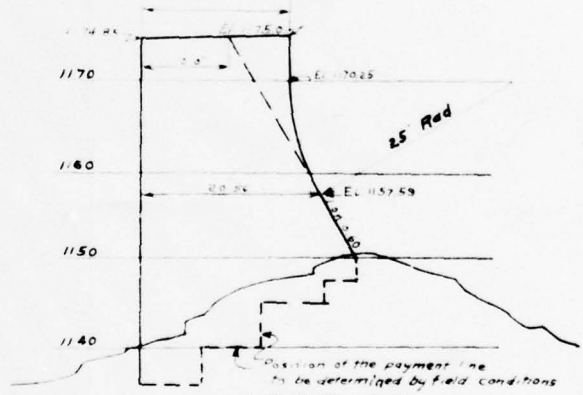


SECTION 3.



SECTION 6.

See also Section AA Sheet 4



SECTION 4.

Sf 1400

ROANOKE VA.

RICHMOND DEVELOPMENT CORPORATION

CARVINS COVE

MASONRY DAM

CROSS SECTIONS

Scale 1" = 10'

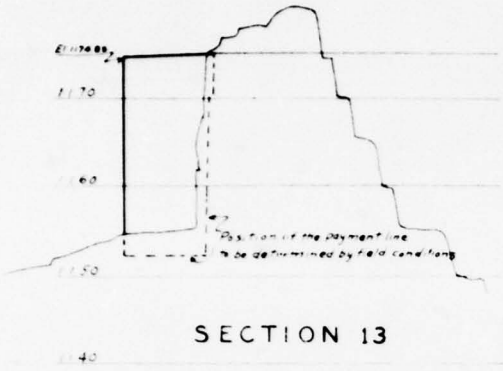
Sanborn & Bogert
Consulting Engineers
New York City

Octr 1926
F3-D4
376-a

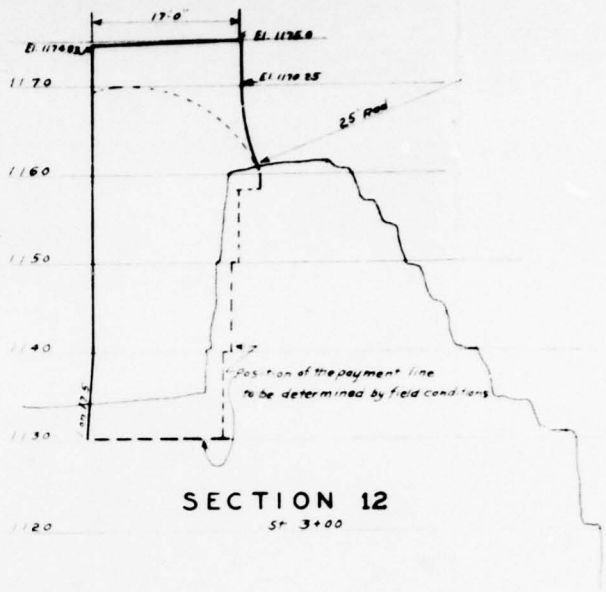
Traced By E.L.A April 6, 1928

2

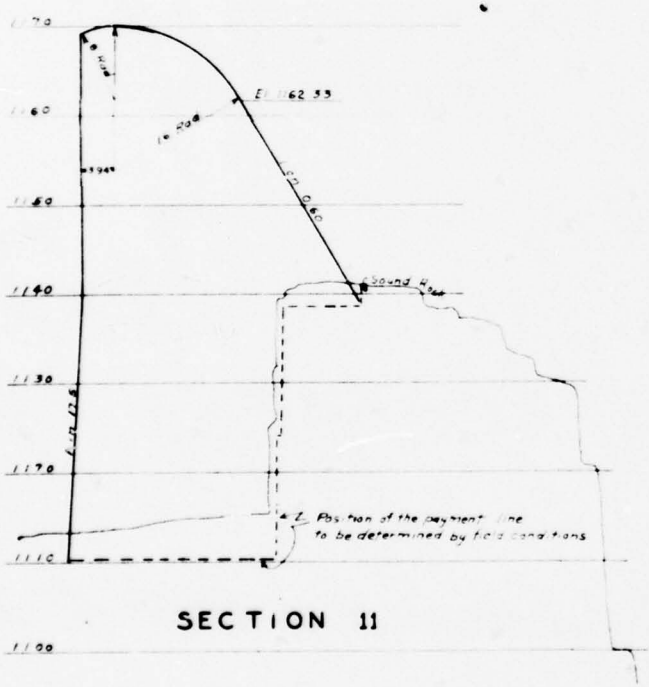
PLATE 4



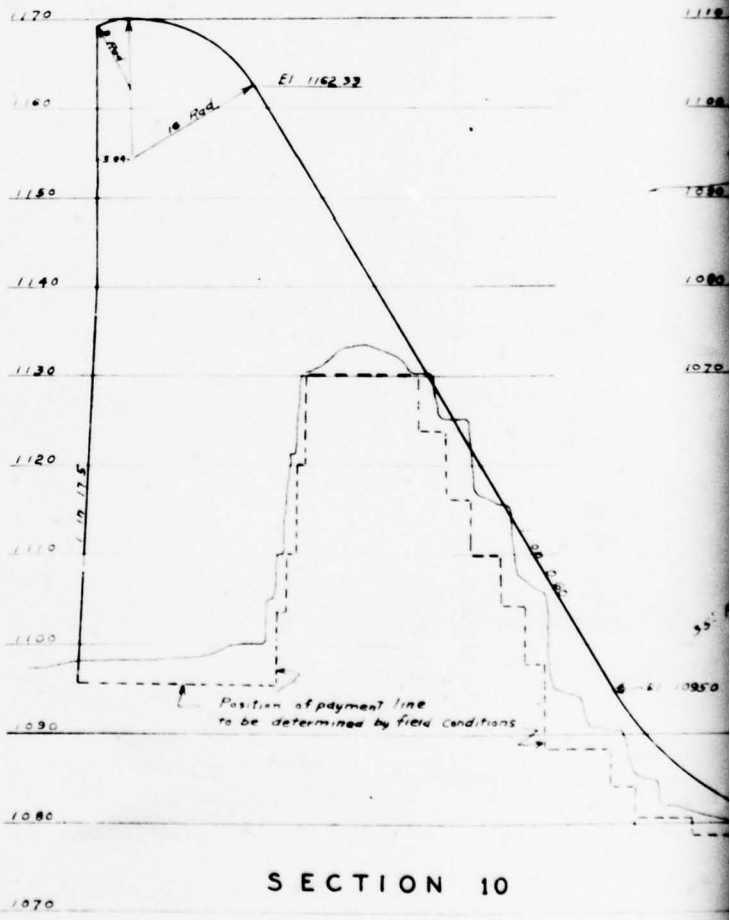
SECTION 13



SECTION 12
Sta. 3+00



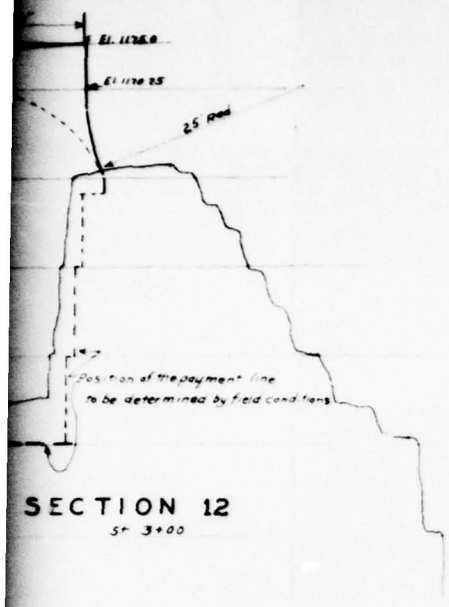
SECTION 11



SECTION 10

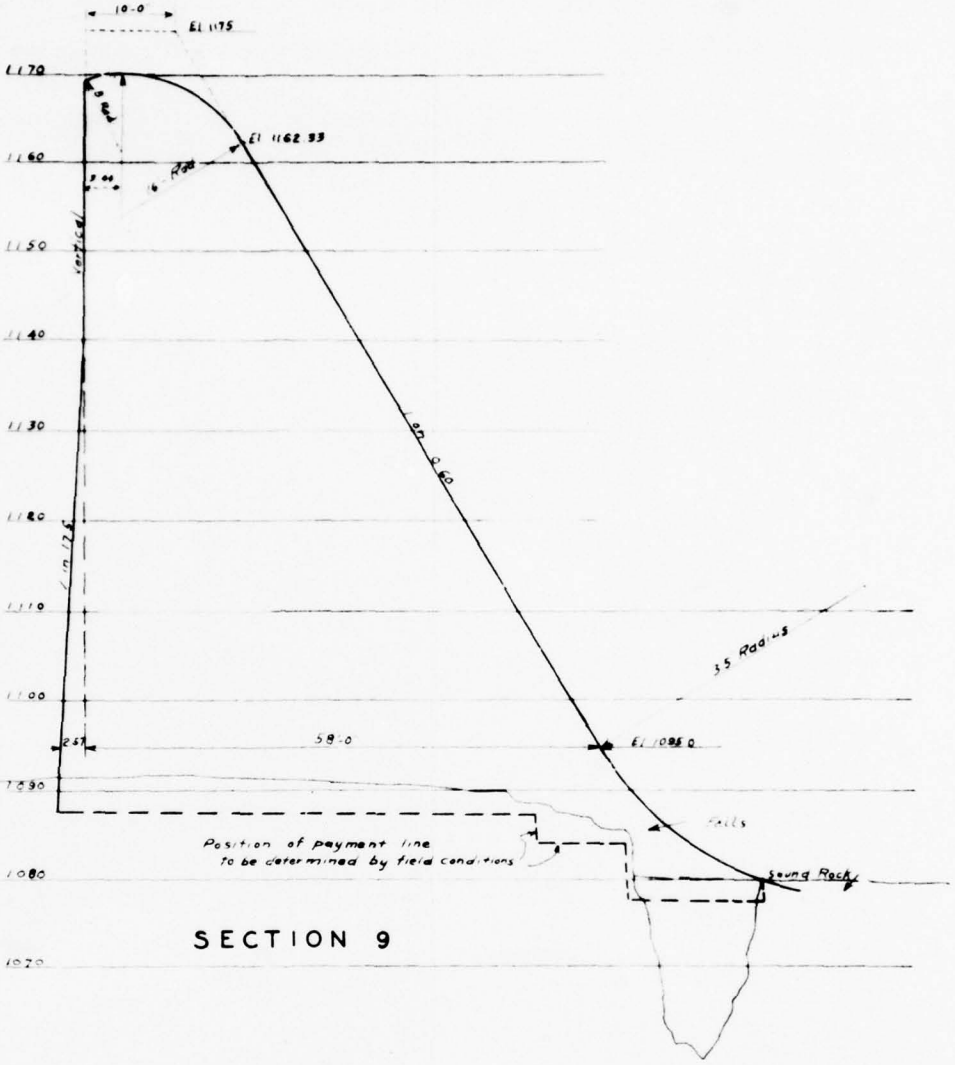
CONTRACT C SHEET 3

5 SHEETS IN SET

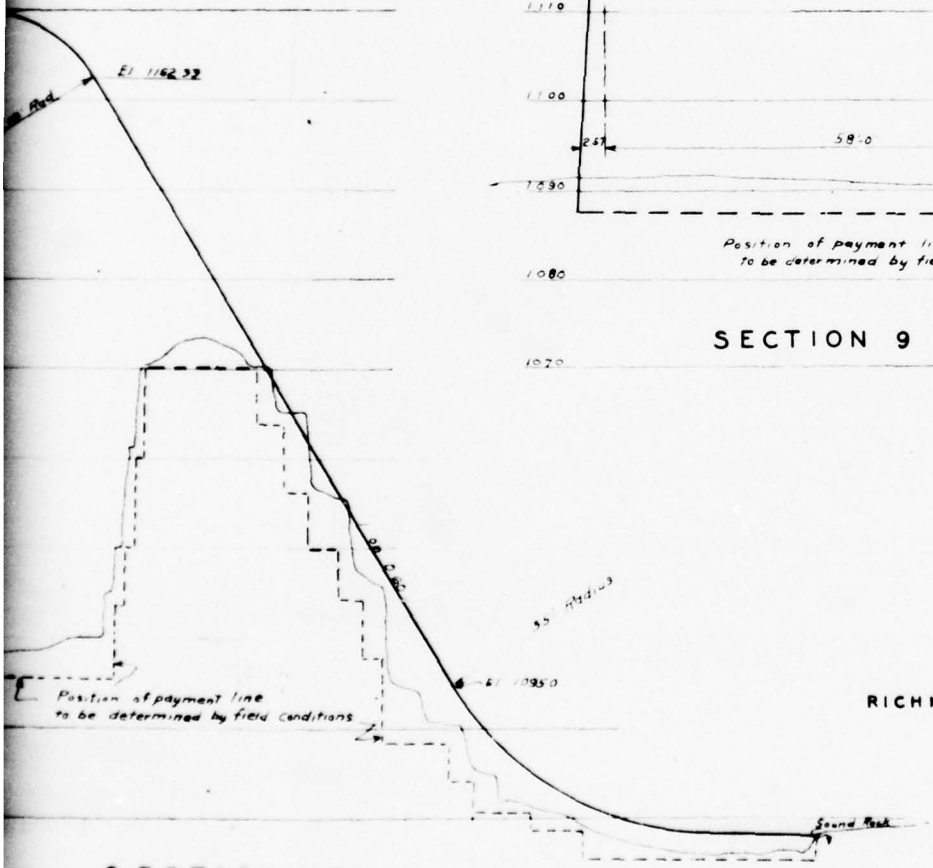


SECTION 12

Sr. 3+00



SECTION 9



SECTION 10

ROANOKE VA.

RICHMOND DEVELOPMENT CORPORATION

CARVINS COVE

MASONRY DAM

CROSS SECTIONS

Scale 1" = 10'

Sanborn & Bogert

Consulting Engineers

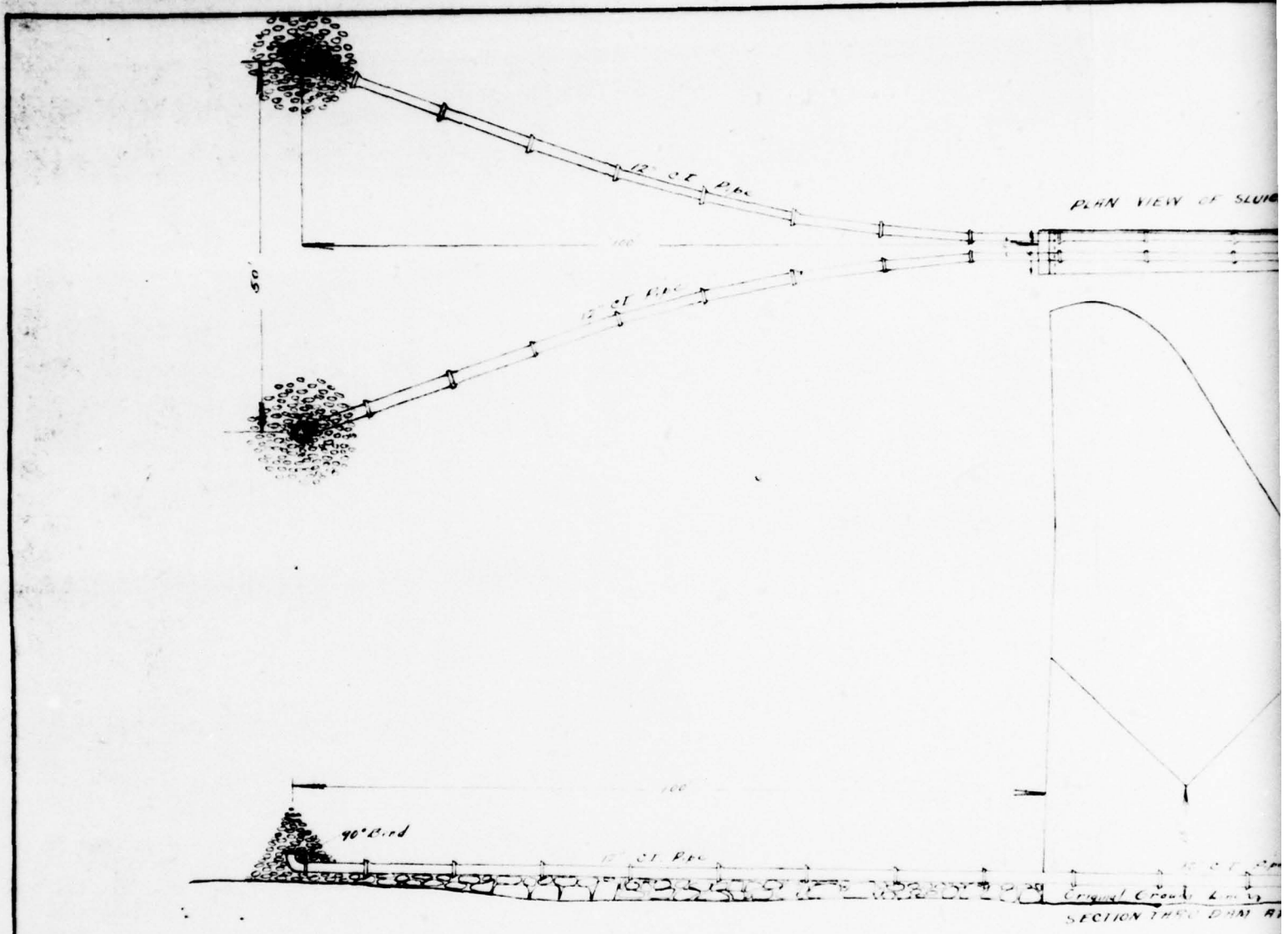
New York City

Oct. 1926

F3-D4

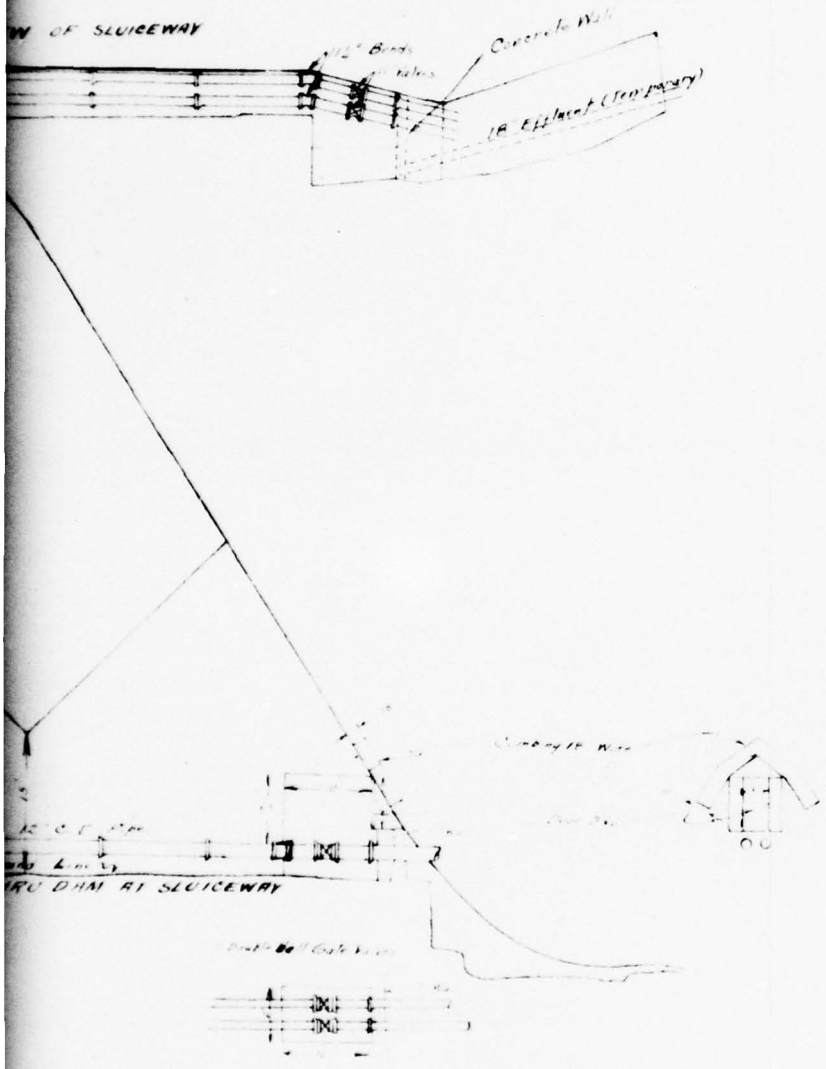
Traced By E.L.A. April, 7, 1972

376-3



1

2



ROANOKE VA

RICHMOND DEVELOPMENT CORPORATION

CARVINS COVE

MASONRY DAM

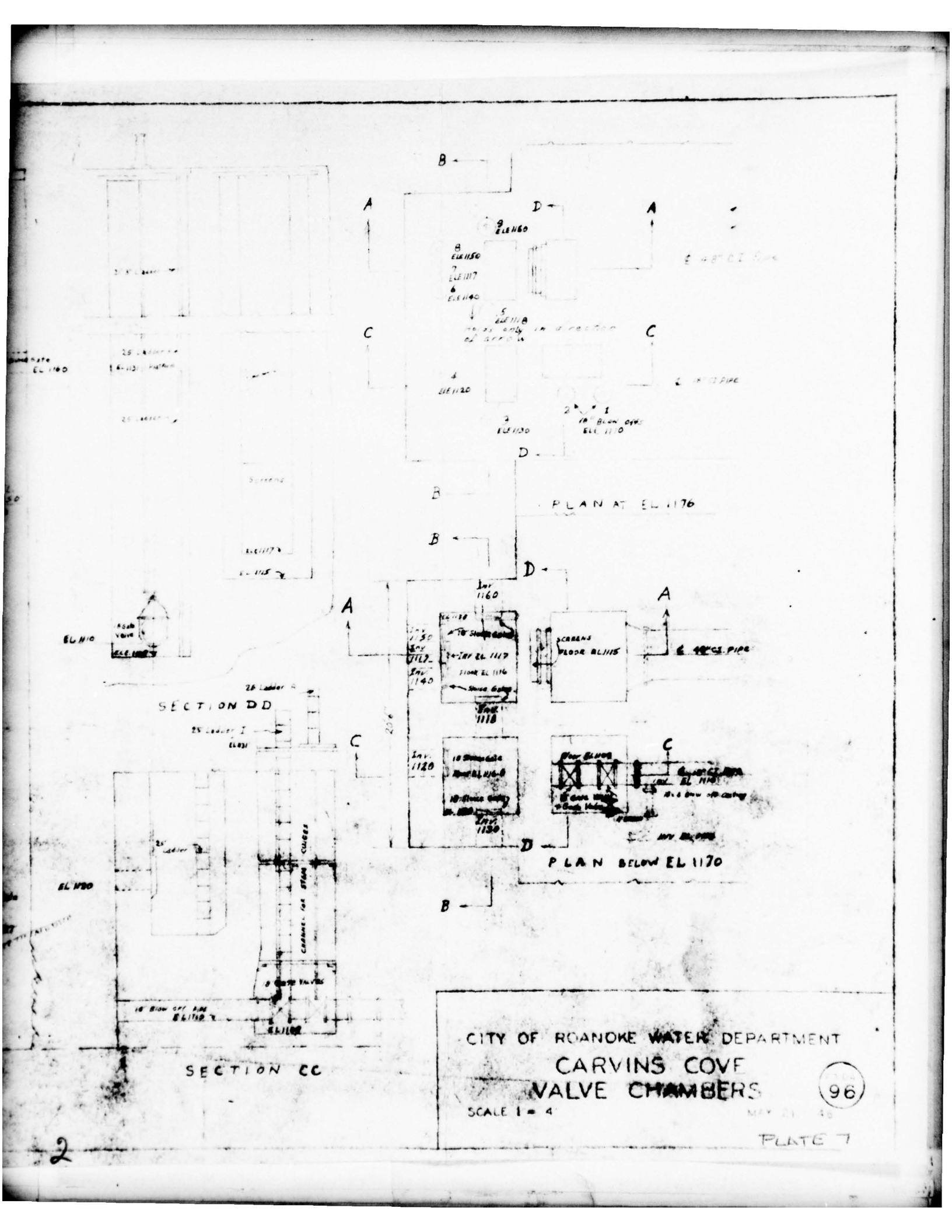
87

2

PLATE 6

SECTION AA

SECTION BB


PLAN AT EL. 1176
PLAN BELOW EL 1170
SECTION DD
SECTION CC
CITY OF ROANOKE WATER DEPARTMENT
CARVINS COVE
VALVE CHAMBERS
SCALE 1 = 4
96
PLATE 7

APPENDIX A

VISUAL OBSERVATIONS AND PHOTOGRAPHS

Carvin Cove
Appendix A
Field Obsevations Taped on Site
Jeff Irving and Carl Anderson

The dam is an 85 foot high cyclopean masonry dam. The water is cresting a few inches over the spillway. The top of the dam is 5 feet above the crest of the spillway. The dam has a width of about 17 or 18 feet. There is a chain link fence that runs down either side on the left abutment section of the dam ending at a house which covers the valve pits. The abutments are large shear rock faces nearly vertical and extending to the peaks of the mountains on each side. There appears to be about 5 or 6 places where there is seepage through the dam to the left of the spillway. The seepage cracks all occur about 17 feet below the top of the dam, all centered, more or less, underneath the house which is over the valve pits. Mr. Sluss stated that the seepage cracks do not flow when the water in the reservoir drops approximately 10 feet. Facial cracking is prevelent on the downstream side left of the spillway. There are large surface cracks which run the full length on the left side, about 17 feet down from the the top, and they seem to be about an inch wide at some points. The left side of the dam tapers from 0 at the top to 85 feet at the bottom. The right side appears to come straight down from the right abutment to the edge of the spillway. There is some flaking on the downstream side of the dam which is caused by freeze-thaw cycles. The downstream face of the spillway has horizontal cracks across it which appear to be on the same lines as the lift lines. The face of the dam is pitted and has large areas flaked off due to freeze-thaw cycles. There are also stains on the face of the dam which appear to be some kind of leaching, probably from a chemical reaction of the concrete and the water. Took a trip down into one of the valve pits. It is 80 feet deep and about 10 x 10 feet square. There are two platforms out of water and one platform under water which could not be reached. There are several cracks in the face of the walls, one has water leaking through it very profusely. It was like a rain shower in the bottom. You see the same kind of leaching stains on the walls that you see on the face of the spillway. This is very prevalent in the valve pit. The downstram area and the dam-foundation interface was observed by Cavan and Anderson. A void located adjacent to the 48 inch raw water concrete protective cover was observed and it extends about 5 feet upstream toward the dam. It is difficult to tell if this void was created during the construction or occured during seepage. There was no evidence of seepage and it is probably a construction feature. There is water along the left abutment area near the contact with the concrete dam, (under the valve house). However, it appears that this is runoff from the above mentioned seeps in the dam. On the right abutment there is seepage at several areas. One zone is on the interface between the apron of the spillway and the right abutment

contact. A zone of poor quality rock was noted in the geology report and this zone is evident in the field and the seep appears to be at the contact between the poor zone and the more sound rock towards to dam. The source of seepage in this zone is undetermined whether it is ground drainage or surface drainage coming down the ravine or if it actually seeping through the mountain from the reservoir. The rock on both abutments is standing near vertical. There is a considerable amount of ice near the concrete-right abutment interface. However, most of this is believed to be from surface runoff where the water flowing over the spillway is hitting a rock outcrop higher up and diverting over the outcrop. In the poor zone on the right abutment there are several areas of seepage coming out of earth and rock materials approximately 50 feet downstream on the right abutment. The elevation of these seepage zones is approximately 1130±. These seeps are not iced over and are producing water which is not frozen. This is definitely believed to be ground or reservoir induced seepage and not flow from the spillway. Temperatures were recorded at 42 degrees F in these seeps. The water appears to be slightly piping some sand material. Joints where seepage is occurring on the right abutment are trending N 65 degrees E. Based on all other geology in the area, the dip would be near vertical, probably a bedding joint. A rough measurement of the quantity is slightly less than 1 GPM. Seepage on the right abutment at the elevation of the apron in the spillway is 40 degrees F. Water spilling over the spillway is approximately 38 degrees F. Mr. Sluss reported that the reservoir water is approximately 45 degrees. At what elevation that is recorded is unknown. In addition to the seeps on the face of the dam reported earlier out near the edge of the spillway, there are also about four smaller seeps in a varying horizontal crack approximately 15 feet below the top of the dam. These are in areas that appear to have been gunited at one time. Reservoir temperature at the dam on the left abutment was 39 degree F. Drawdown of the reservoir can be accomplished by utilizing the two 12-inch conduits at the base of the dam, the 18-inch blowoff line which is located approximately 20 feet above the 12-inch conduits and also the 18-inch blowoff downstream in the creek which comes off the 36-inch line feeding the filtration plant. This is the only way that the reservoir could be drawn down in the event of an emergency.

Geologist's Report on the Inspection of Cavins Cove Dam

On the 27th and 28th of December 1977, an inspection of Carvins Cove Dam was conducted. The inspection included a review of construction and design documents, available geologic data, and field inspection of the dam site. The following is a report of this inspection.

Carvins Cove Dam is located northwest of Roanoke, Va., in the Appalachian Valley and Ridge Physiographic Province. The dam is sited in a natural gorge through a prominent ridge on the southeast limb of a large syncline. It is the old site of a falls and is well documented in the geologic literature for the area.

Initial geologic investigations for the proposed dam were done by Prof. Charles P. Berkey in 1924. He was then a consultant for the Roanoke Water Works Company. He judged the site to be "ideal" for "a small reservoir" and "perfectly safe geologically". The dam is situated on top of and abuting against vertically dipping quartzite of Silurian age. The quartzite in the foundation and abutments of the dam is a white, friable, coarse grained, sandstone (Clinton Fm). Immediately downstream of the dam,white to red sandstones and shales along with a grey quartzite (Clinch Fm), can be found. Upstream of the dam, the literature is consistent in describing the presence of Devonian shales and thinly bedded sandstones. Some mention was made of the presence of the Helderberg Group in the vicinity of Carvins Cove, not as a limestone, but thinly bedded chert and shale. No inspection of the outcrops upstream of the dam in the reservoir area was made.

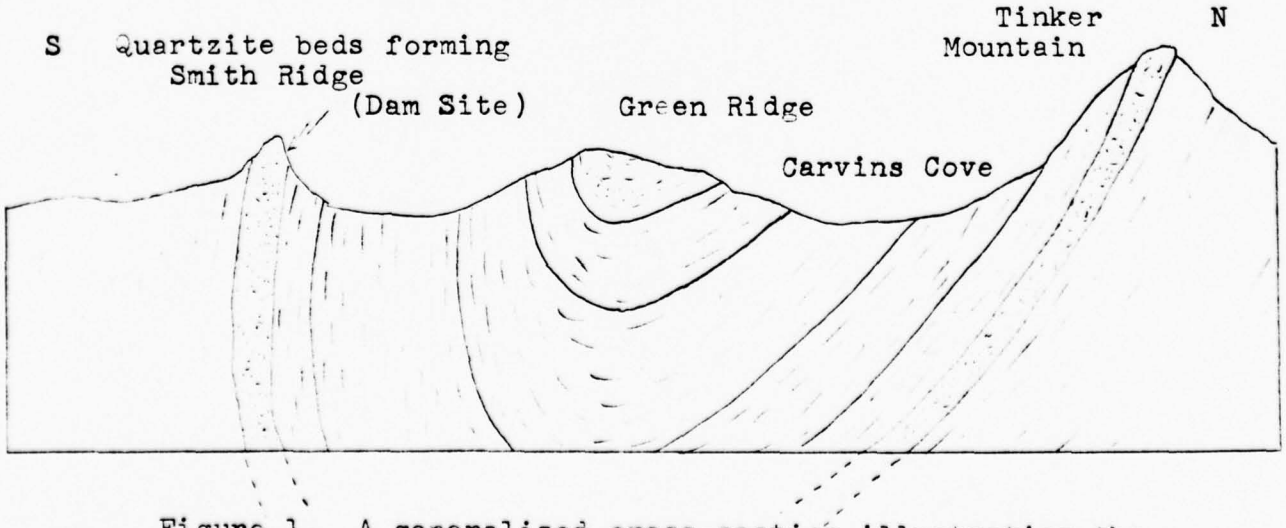


Figure 1. A generalized cross-section illustrating the ridge development and general structure at Carvins Cove. (Berkey 1924)

There is no record of any special foundation treatment being performed at the dam site. There were provisions in the contract documents for grouting under the dam if necessary, however, there are no records of any actual grouting being done. The need for such treatment does not seem to exist. The predominant joints in the dam site trend N55°-60°E (parallel to the dam) and dip 85°SE to vertical. These can be considered bedding joints. Several other joint trends are present but only one is significant. These joints trend N45°-50°W and dip 79°NE. They are, however, tight with no indication of enlargement or clay filling.

The contact of the dam with the abutments was very tight where observed. Some minor seepage from the spillway was evident on the right abutment, however, it seemed to be controlled by the natural jointing in the rock. Several small springs were observed approximately 50' downstream of the dam on the right abutment. The springs were located between one-third and one-half the way up the abutment. The flow appeared to be along the bedding (parallel to the dam), and some sand was observed to be carried along by the water. The approximate flows were estimated to be just less than one gallon per minute. Temperatures taken at the springs were observed to be 42°F, the temperature of the water at the surface of the reservoir was 39° and 38°at the spillway on this day.

The rock materials for the dam were taken from a quarry located approximately 200' downstream from the dam on the left abutment. The massive quarried stones used in the cyclopean concrete structure, were quartzite (Sp Gravity 2.65-2.68). Samples of the concrete taken from various places on the downstream face of the structure showed a high percentage of quartz sand, pebbles, and chert fragments. These materials have a high thermal expansion and in the case of the chert are alkalai reactive. This may explain some of the pattern cracking on the structure. There were apparently no quarrying operations carried on below the existing level of Carvins Creek.

The dam site appears to be an exceptionally good one geologically. The site is located in Seismic Zone 2, and a study prepared for the Veterans Administrative Hospital in Salem, Virginia indicates a horizontal ground acceleration about 0.1g. It should be noted here that detailed geologic mapping of the Carvins Cove area is not available. Such mapping, if available should be reviewed. See reference 1, comments.

Due to the predictable structure of the rocks at the dam site, no core drilling was performed either before or during construction. The presence of the Devonian shales upstream of the dam and quartzite at the dam site would preclude the formation of any extensive cavities or related foundations problems at the dam site or in the reservoir area.

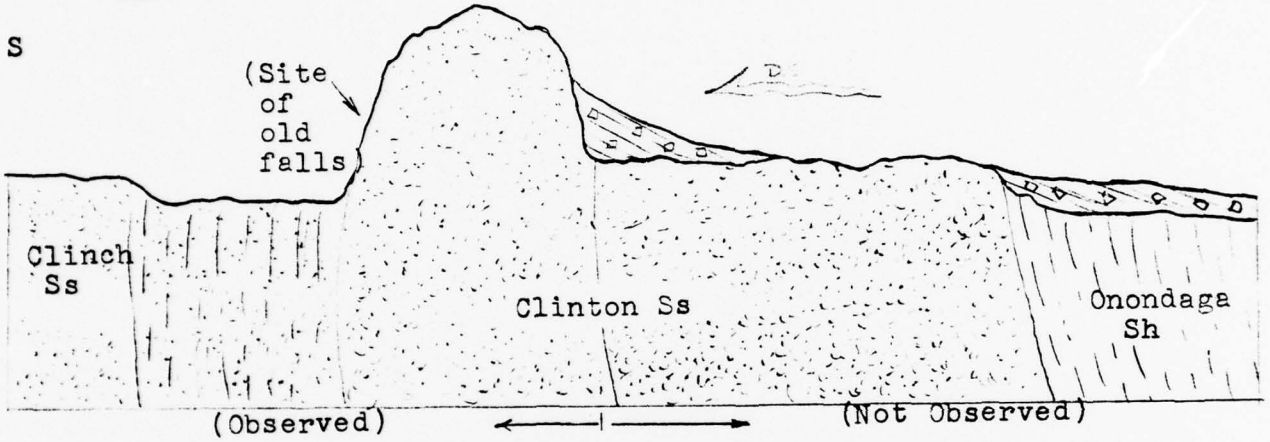


Figure 2. A generalized section taken normal to the dam alignment to illustrate the lithology of the dam site. (after Berkey, 1924)

Further foundation investigations at this time, other than observation of the springs on the right abutment, would seem to be unwarranted.

Bruce P. Cavan
Geologist

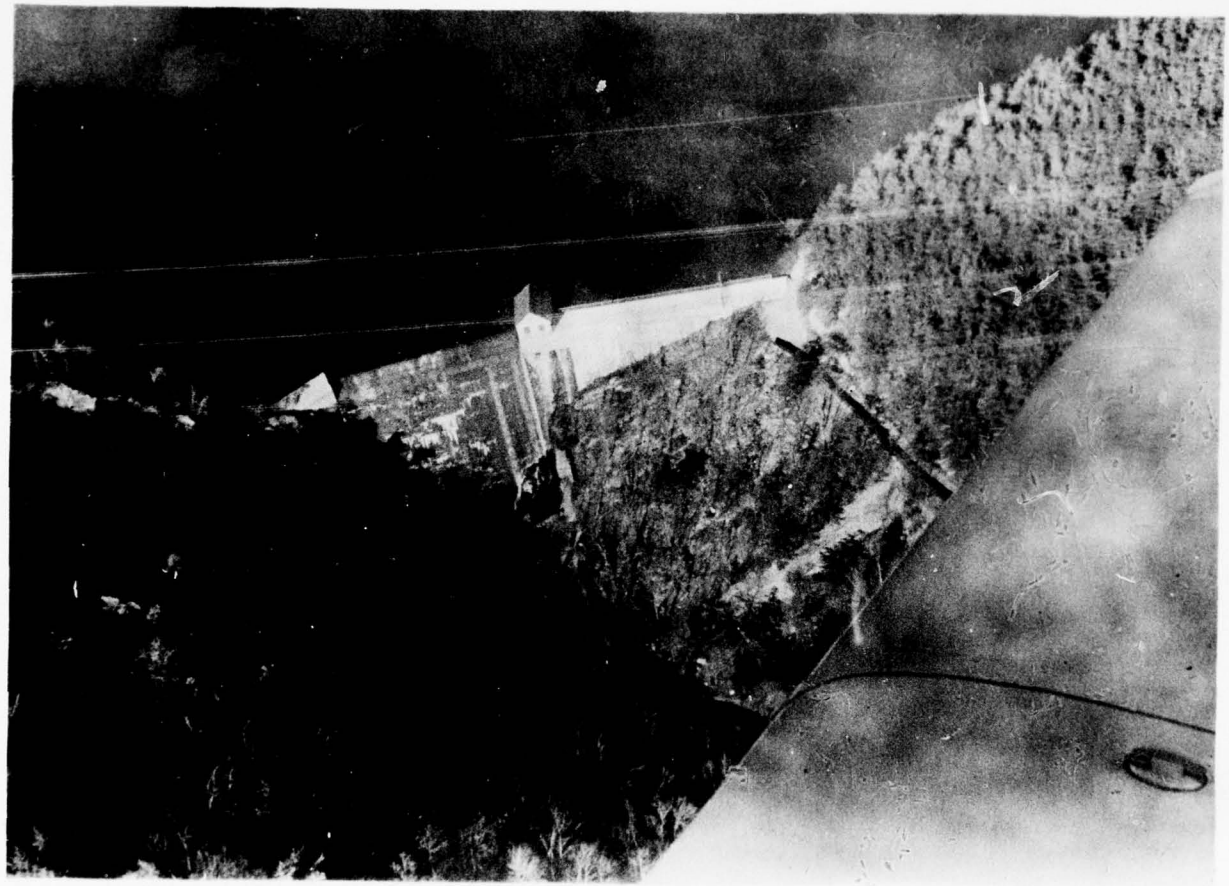
References:

Berkey, Charles P., Geologic Report & Comments, 1924, N.Y.

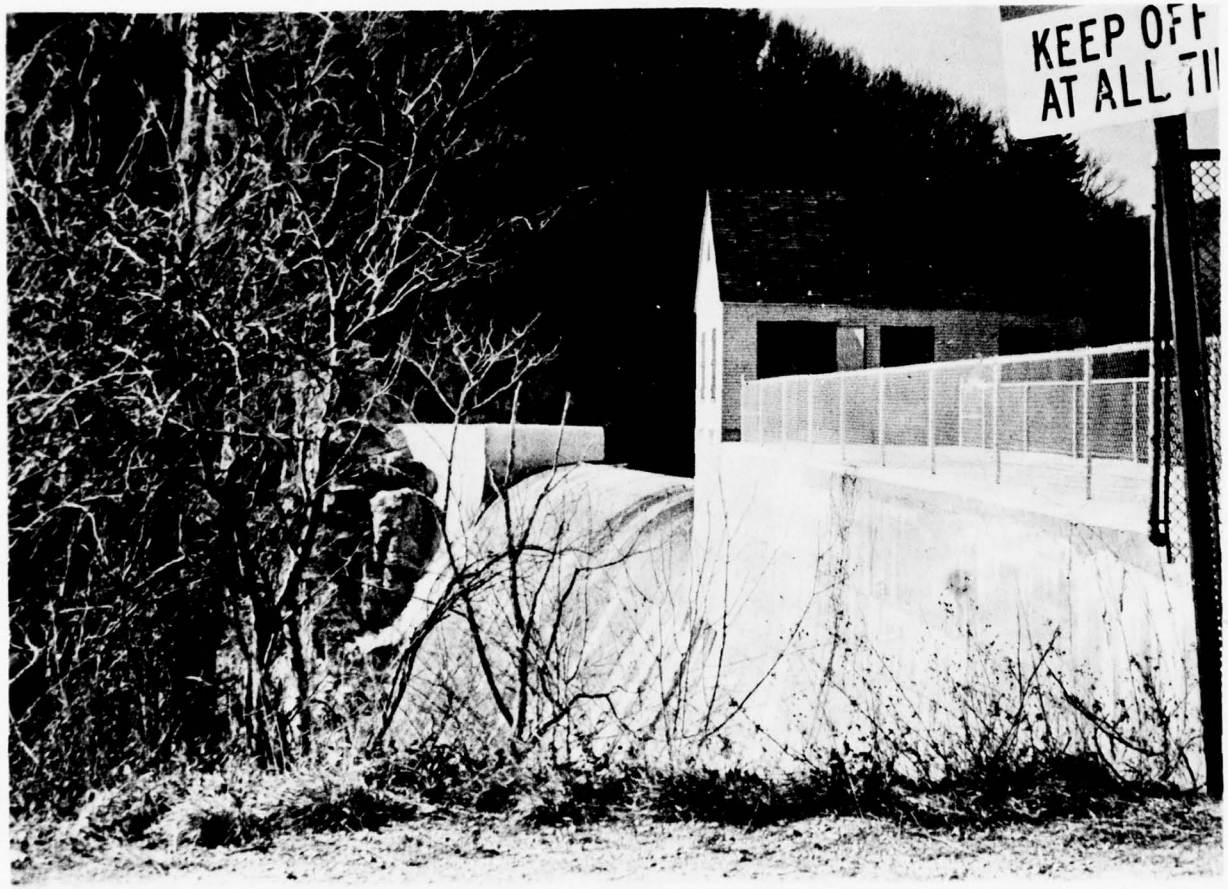
Butts, Charles, Geology of the Appalachian Valley in Virginia, 1940, University, Va.

Woodward, Herbert P., Geology and Mineral Resources of the Roanoke Area Va., 1932, University, Va.

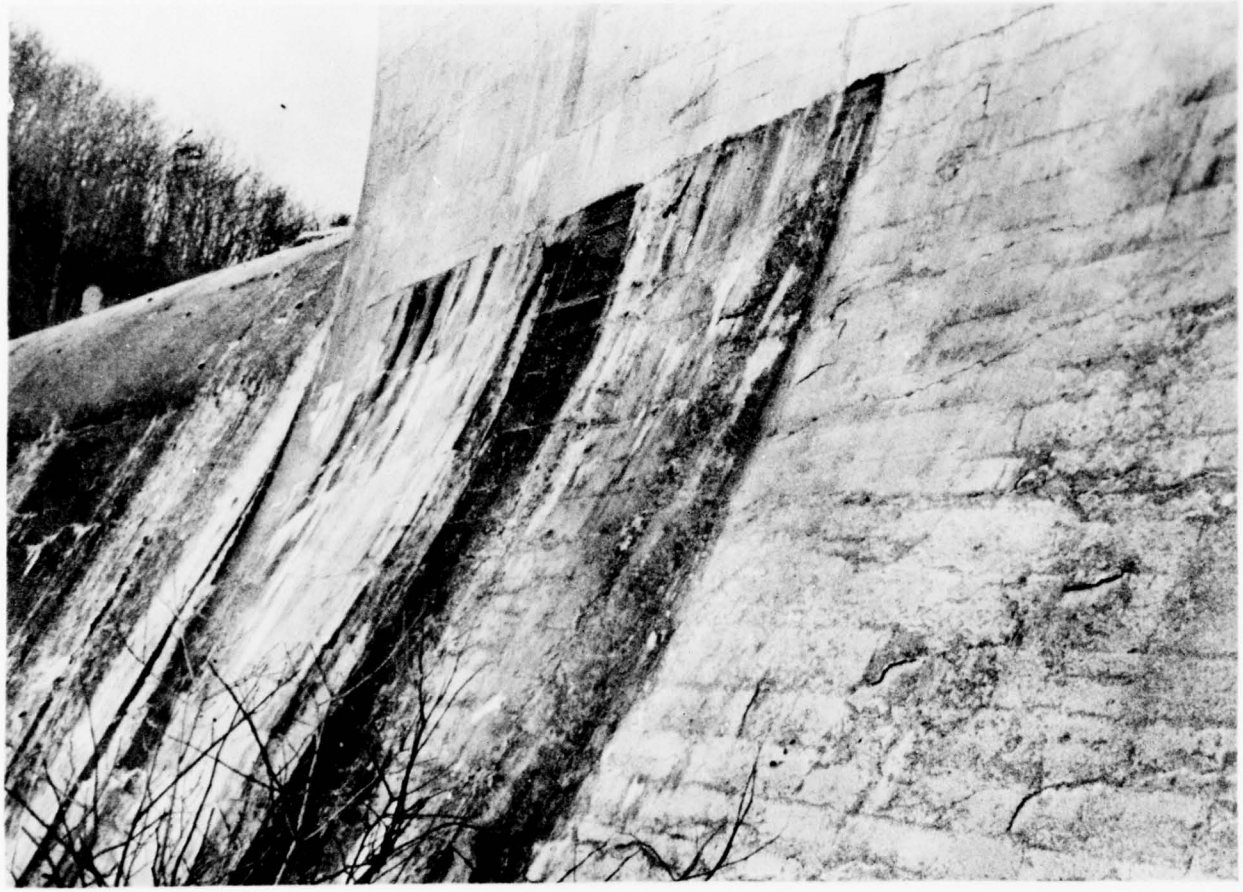
Water Department, City of Roanoke, Construction records and Photographs, 1927, Carvins Cove Dam.



CARVIN COVE DAM - OVERVIEW SHOT



CARVIN COVE DAM - VIEW FROM LEFT
ABUTMENT SHOWING VALVE PIT HOUSE
AND SPILLWAY



CARVIN COVE DAM - SEEPS IN DAM
UNDER VALVE PIT HOUSE

CARVIN COVE DAM - CARVIN CREEK
IMMEDIATELY DOWNSTREAM FROM DAM

APPENDIX B

GEOLOGISTS REPORT
BY
CHARLES P. BERKEY

NEW YORK CITY
MARCH 1924

FIELD REPORT

on

An Additional Water Supply Problem

At Roanoke, Virginia.

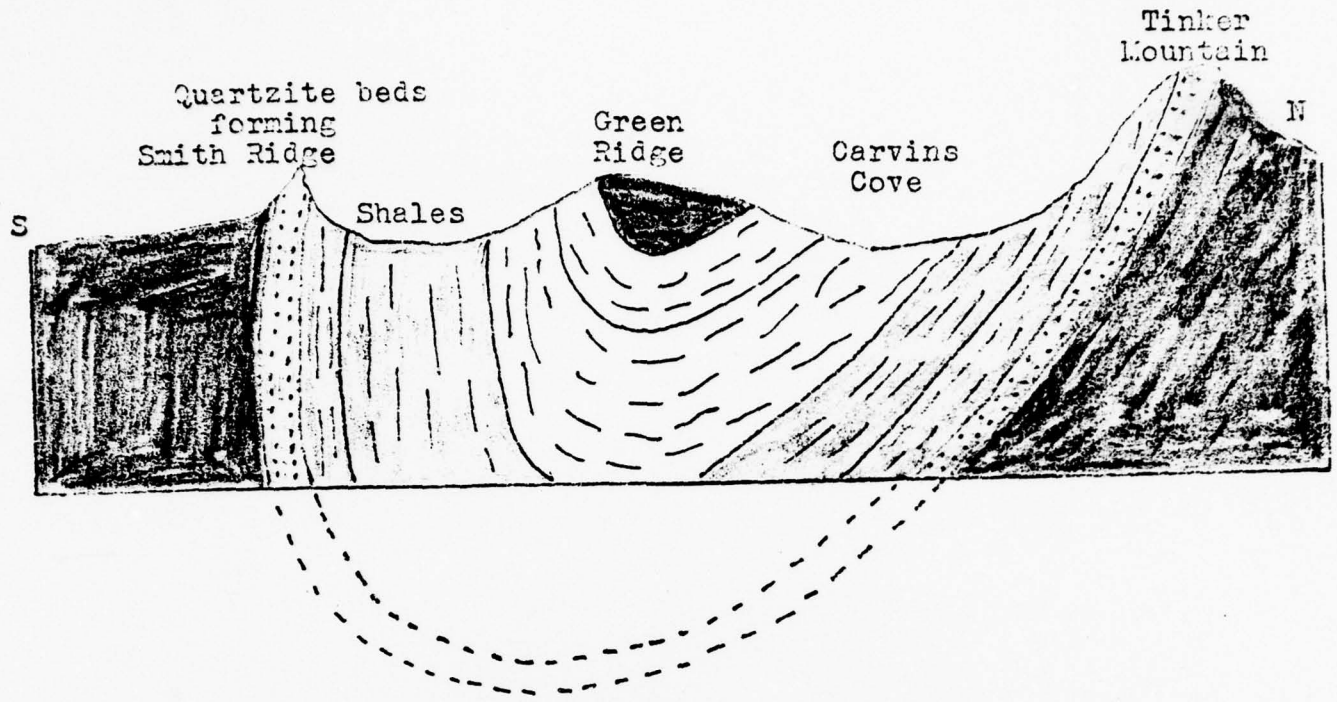
On February 24 and 25 a field inspection was made of the physical conditions prevailing on the ground being considered as a possible additional water supply in the vicinity of Roanoke, Virginia. The principal problem and the one directly responsible for this personal examination is the question of feasibility of a certain dam site, together with the question of possible exploratory requirements looking to the full determinations of this question.

The location lies six miles north of Roanoke. At this point a small stream, Carvins Creek, cuts through a pronounced narrow ridge of very hard rock and constitutes the only outlet for all of the drainage of Carvins Cove and the area lying between Smith Ridge, Green Ridge, and Tinker Mountain. A very promising small supply of water of excellent quality is gathered in this cove and the local topography is of favorable form for a reservoir. The only problem of much consequence, therefore, is that belonging to the ground at the dam site itself.

Major Factors and Observations.

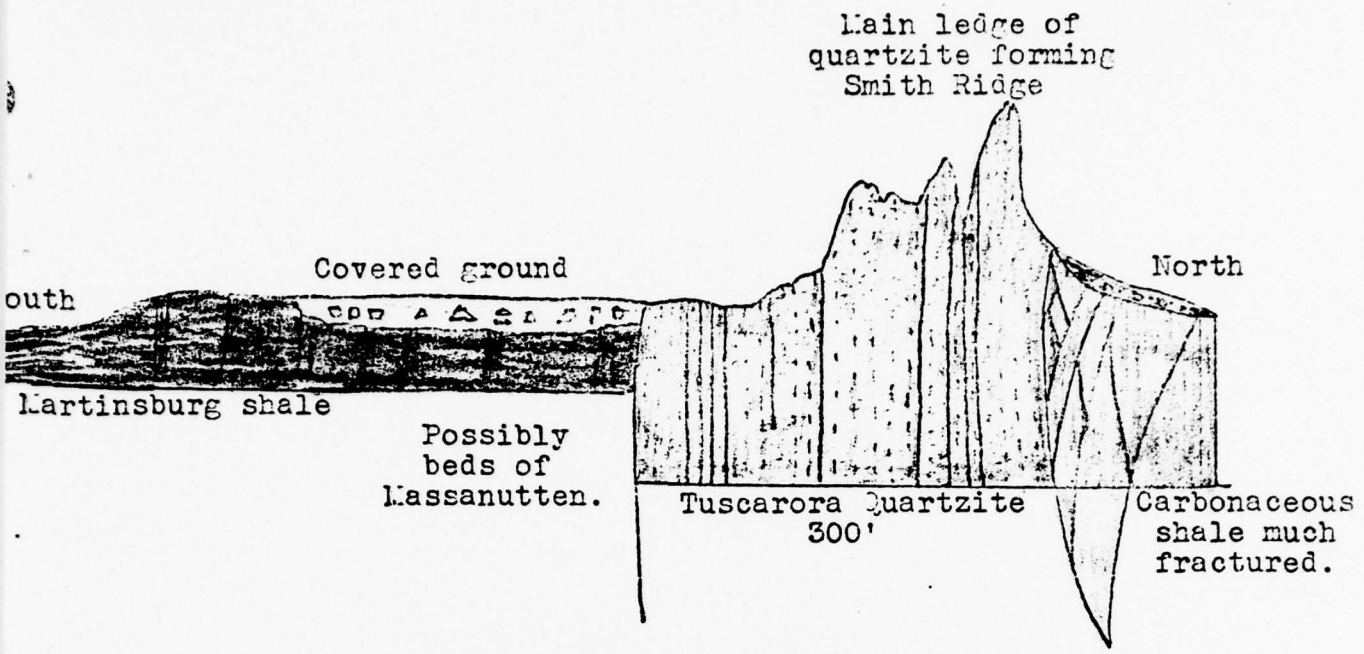
An examination of the ground shows beyond question that these mountain ridges including Tinker Mountain, are formed by the upturned edges of hard strata which together have been folded into a great synclinal trough extending northeast and southwest for many miles. The northwestern limb of thissyncline is very well developed in Tinker and Catawba mountains, whereas the southeastern limb, represented in part by Smith Ridge, is much less prominently developed and considerably obscured by more complicated structural disturbance. As a consequence, the rim does not form as perfectly or as continuously on the southeast side of this great syncline as it does on the north and northwest side. A part, however, of the southeast rim is preserved in Smith Ridge which crosses Carvins Creek at the fall and forms the dam site covered in this examination and the principal interest of this report. The rock here at the site is undoubtedly a continuation of the same rock formation referred to as forming the rim of the synclinal trough and now standing up in relief in the form of mountain ridges.

This structural relation is of importance in gaining an understanding of the ground at the dam site where a quartzite formation 300 feet thick stands up exactly on edge. This undoubtedly is simply one limb of the eroded syncline and this same formation must certainly go down and beneath the cove and rise again on the northwest side in Tinker Mountain. Thus the structural relations are comparatively simple, in spite of the fact that all of the formations have been so extensively folded and eroded.



Generalized Cross-section intended to illustrate how relief differences are developed on this synclinal trough involving a thick series of sedimentary formations in which two very hard layers of rock serve as the guiding factor. The chief ridges are formed where the hard layers or rock come to the surface.

In the vicinity of the proposed dam, shales of the Martinsburg formation and perhaps also sandy shales of the Massanutten formation lie beneath (southwest of) the quartzite formation, judged to be the Tuscarora quartzite that forms the ridge. This quartzite comes next upstream, standing on edge with a thickness of at least 300 feet, and above the quartzite (northwest) black carbonaceous and sandy shale are the only rocks exposed to as great a distance as investigations were carried in that direction. A sketch cross section of the structure at this point is indicated in the accompanying figure.

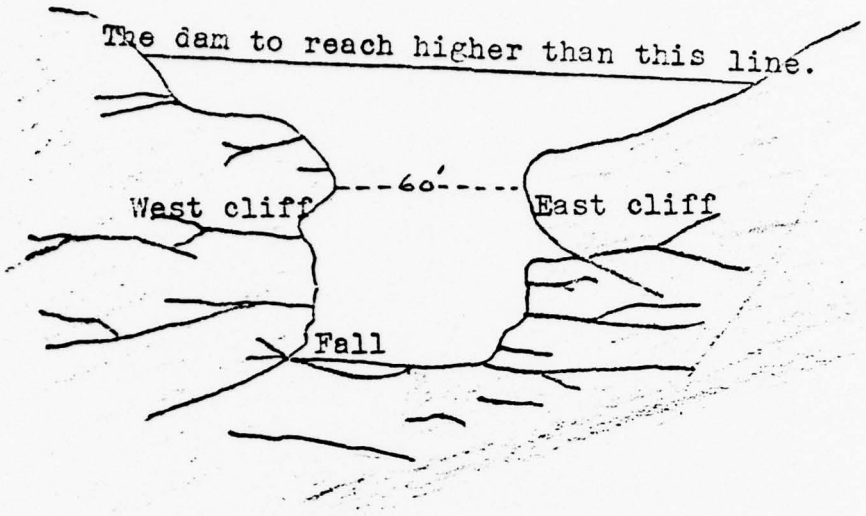


A sketch Cross Section of the rock formations at the immediate site of the proposed dam, showing the Tuscarora quartzite, 300 feet thick, standing on edge, the Martinsburg shale below, and the carbonaceous, much fractured shales above this member.

This is designed to illustrate the structural relations of the rock formations.

The important thing here, of course, is the fact that the quartzite formation, which is 300 feet thick and stands up on edge, is so hard and resistant to erosion that it forms a barrier ridge and on this the fall in the stream is developed. Thus the stream flows over solid rock at this point and has cut a very narrow notch, giving an excellent setting topographically for a dam.

If a dam could be located on this main ledge, it would apparently have a sound foundation and excellent supports for the two ends. The chief question in connection with the problem in this form is whether, after all, the foundation is as sound and continuous as it looks, or whether there is some other structure beneath that could in any way endanger it.



The notch cut through the main quartzite ridge by Carvins creek, as seen looking up stream. The irregular jointing of the rock ledges is shown, but the bedding structure runs from right to left and cannot be shown in this section.

Particular attention, therefore, was given to this point. I have taken pains to examine the main ledge which forms the lip of the fall and the beds that lie both upstream and downstream from this ledge with the idea of determining whether they also are substantial enough for the purpose and whether there could be any underlying weakness or change of formation immediately beneath the site.

I have come definitely to the conclusion that the foundation of the site is sound, that the beds must extend downward almost vertically much farther than can by any possibility be demanded by the needs of the site. It is absolutely certain that this formation stands on edge and must continue downward a considerale distance before it turns beneath the shale and comes up again on the far side of this synclinal fold. The rock itself is sound, being a quartzite of heavy bedded structure. There is no possibility of it being cavernous or

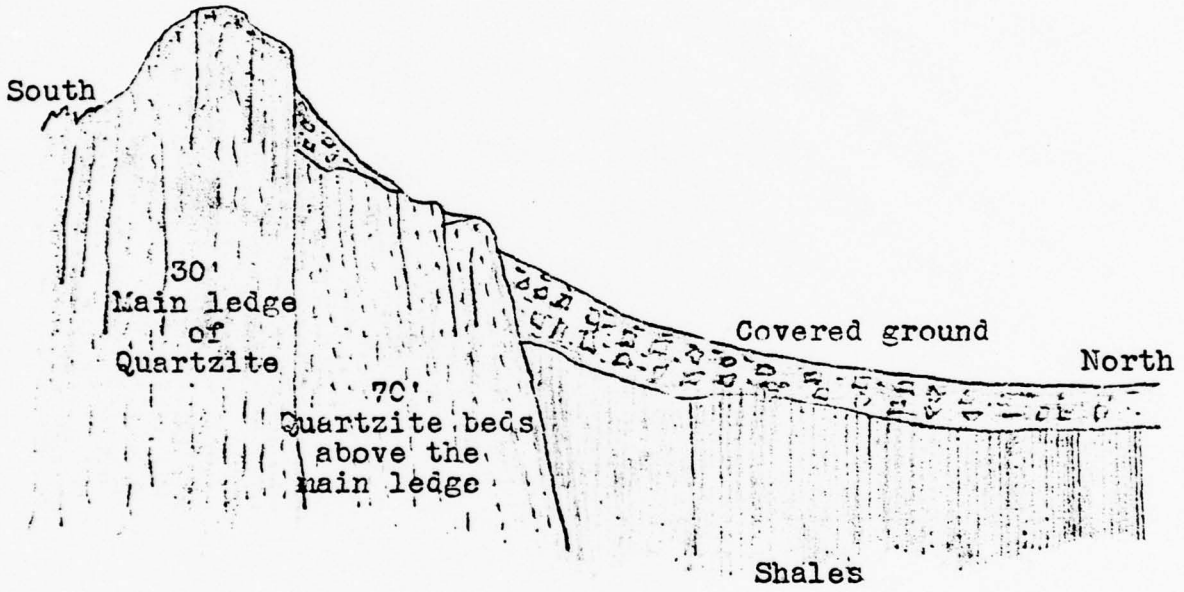
very porous or in danger of being weakened materially by additional water circulation. There is, therefore, nothing to be gained, in my opinion, by exploratory boring into the foundation itself. This expense can safely be eliminated. The most substantial and massive beds of this quartzite formation form a belt about 30 feet thick. These beds form the sharpest and highest portion of the ridge and also constitute the solid ledge over which the waters fall. These beds I shall refer to as the main ledge. This main ledge is the basis of this dam site.

The quartzite beds belonging to this same formation that lie on the upstream side of the main ledge at the fall are not more than 70 feet thick and are also not quite as substantial and undisturbed as are the main ledge beds. They have a thinner stratification and are in places somewhat weakened by the folding movement, but they will give absolutely secure foundation for any structure that need be thought of in this connection. Beyond that point, 70 feet upstream from the main ledge, the floor rock is shale and this is not nearly so substantial a type of rock. Therefore, no heavy structure ought to be designed that would extend more than 75 feet in front of the main ledge unless it be of the nature of earth fill. An earth dam of course might safely overlap any kind of ground that is to be found in front of or on either side of these ledges.

The ground immediately in front of the main quartzite ledges at the fall are somewhat covered with fallen blocks and other debris belonging to talus accumulation and residuary soil and stream wash, so that the rock floor in front of the main site can not be seen, and the depth of the cover is somewhat uncertain. It can not be

very great, however, because of the fact that the erosion is entirely stream erosion and it has surely not been possible for the stream to cut much deeper into these formations thant the ground over which it flows at the present time. A very little stripping, therefore, would undoubtedly expose the rock floor on any of this ground.

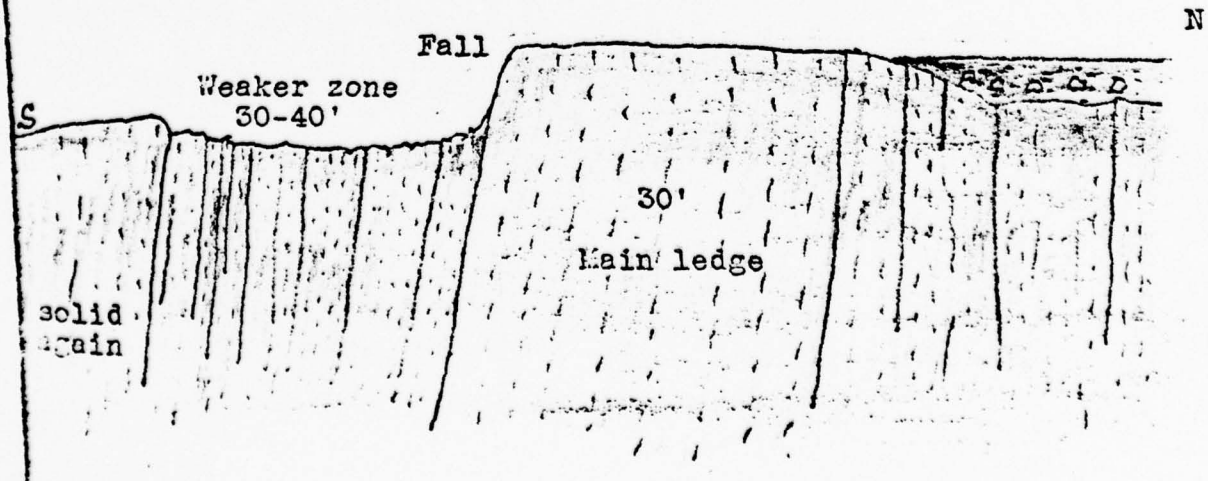
A cross section designed to illustrate
the relations of ledges to covered ground.



The quality of the cover on top of the rock floor immediately in front of the main ledge is somewhat less certain. The material is made up doubtless of blocks of quartzite and fragments of shale and some more disintegrated soil mixtures, but it can not be very good quality and probably will require removal wherever the foundations are to be laid, no matter what kind of design is adopted. It might be desirable to put down a test pit in this material at one or two points within reach of the principal operations, simply to see what the quality is and how deep it is to rock. These points have to do with construction estimates.

The ledges immediately behind (downstream from) the main quartzite ledge at the fall, for a distance of 30 or 40 feet, are thin bedded and show some slipping (bed faulting) between the beds so that there is somewhat more weakness in this zone of 30 or 40 feet than in most other portions of the quartzite formation. This is reflected in the local topography of the ledge, for it is marked by a depression taken advantage of by the fall and this is continued on both sides of the stream, as well as in the bottom. It is this ground that breaks away a little better or a letter faster than does the main quartzite ledge. The weaknesses that are in it, however, run practically parallel to the bedding and are essentially tight. A little circulation, doubtless, could take place along these weaknesses but they run parallel to the ridge instead of across it. Therefore, they are of little consequence in considering any possible loss of water through the ledge and dam.

Cross section designed especially to show the position of the zone of somewhat weaker rock below the main ledge.



This zone, however, is one that should not be disturbed unnecessarily. It should not be subjected to extraordinary demands such as might be placed on it if the spillway were allowed to discharge directly into this zone. Whatever is done in the matter of spillway arrangements should take this into account and the spillway should lead across this zone before discharging the waters. No other precaution is necessary.

The ledge referred to as the main ledge sticks up more massively and higher than any of the others and is approximately 30 feet thick. It has very few cross fractures. An occasional one connected with the disturbances that folded the rocks and caused them to stand on edge does, however, reach through considerable portions of the ledge and would allow some small seepage or circulation across the structure. These it will be necessary to seal up as effectively as possible and I am sure that this can be done by the simple processes of grouting. Arrangements should be made in connection with the design and construction of the dam to place pipes at convenient points for forcing grout into these crevices. This will undoubtedly eliminate all important weaknesses of the kind.

General Conclusions.

1. The location is an ideal one for a small reservoir and an economical dam.

2. The site chosen for the proposed dam on the main ledge forming the fall in Carvins Creek is an eminently feasible location. It is perfectly safe geologically. The foundationsof site are sound and undoubtedly the same rock extends to much greater depth than can by any possibility be required.

3. There is absolutely no need of special exploratory borings on this site. The conditions are understandable and simple, and work of this kind might as well be saved, because it does not promise additional information of sufficient value to warrant this expense.

4. The quality and thickness of the ground cover on top of bed rock immediately in front of the main ledge of the fall is less certain. It would probably be of real advantage for the purpose of design and estimate to determine these two points by the digging of a couple of test pits into the ground within reach of the proposed structure. Care should be taken to guard against caving or accident if these pits should go more than two or three feet deep.

5. Any design can be adopted that will make full use of the main ledges at this point. The question is one largely of economy of construction and availability of structural material. Probably some form of concrete dam is as economical as can be constructed under the circumstances. A masonry dam, of course, is entirely feasible and there is plenty of structural material for it.

On the other hand, an earth dam which would also be feasible would probably find more difficulty with supply of structural material. It is not certain from the observations made on the ground that an adequate supply of heavy material for fill is at hand. The soil cover is comparatively thin and of comparatively poor grade and porous. If an earth dam were made, unusual care would have to be taken to construct a core wall to act as the chief barrier to water seepage. On these accounts probably some form of concrete dam would be suitable. The foundations are ideal and the supporting side-walls are particularly good for this kind of a structure.

6. In connection with the design, arrangements should be made to carry the spillway down stream at least 50 feet beyond the main ledge so as to cross the somewhat weaker 40 foot zone that lies immediately back of or below the fall. The discharge can be cared for anywhere beyond that point without any misgivings about the behavior of the ground.

7. As an aid to studies of design and cost, it would be of advantage to have a detailed map of the ground in the immediate vicinity of the proposed dam. This should be on a comparatively large scale, about 100 feet to the inch, with five-foot contours and the area should extend both above and below the quartzite formation onto the shale areas, forming the ground both upstream and down, and should include corresponding territory on both sides of the stream. This map should take in enough territory so that all operations connected with construction work could be located and shown on the same map.

In addition, a still more detailed topographic sheet should be made of the immediate dam site. It is suggested that this be made on a scale 25 feet to the inch, with two-foot contours as a basis for computations in connection with design and construction. This need not extend much beyond the actual construction limits, but should be quite accurate within the range of these operations.

8. In connection with this mapping work, an accurate cross profile should be made on the main ledge drawn to normal scale, parallel to the course of the ledge so that measurement and proportions can be taken from it direct.

9. The problem of delivery of this water to the City is still unsolved by any of these observations. Available data are quite insufficient to pass any judgment of value to this purpose. I suggest that a topographic route map be made between this reservoir site and the City of Roanoke, following a fairly direct line, but certainly covering the most direct highways between the two points for the purpose of determining what actual conditions have to be met. It is entirely likely that steel pipes of sufficient strength to carry the supply under continuous pressure would be the most economical and successful form to adopt, but I am not sure that this conclusion can be drawn from the data in hand and I suggest that such a map be made to accompany the other studies.

New York City,
March 1st, 1924.

Charles P. Berkey,
Consulting Geologist.

MEMORANDUM

on the

PROSPECTIVE DEVELOPMENT AT

CARVIN'S COVE NEAR

ROANOKE, VIRGINIA

This memorandum is intended to cover one or two points in connection with the proposed dam at Carvin's Cove. I do not undertake to advise on the type of dam best suited to the case. I am assuming that an earth dam with a core wall could be constructed, and would be safe, and that it would probably be the most economical design. If this is not true, my comment has no significance.

If such a dam is feasible, I believe that one could safely take advantage of the first bold quartzite ledges that project out into the gorge and stand up like a wall, using them as a part of the core wall of the dam. This prominent quartzite ledge is sound and there is no danger of it giving way or weakening by water seepage. If the gap were filled in with a sufficiently substantial and tight core, I am sure that the ledge will do its share in completing the core wall.

Seams and grouting

The rock both of the ledge and of the foundation is substantial and sound and not liable to appreciable

destructive attack by circulating water. There are, however, a good many joints in the upper exposed portion, and this should be grouted as a check against seepage. There is no necessity, it seems to me, to plan a grouting program beneath the foundation, but I do think that the upper ledges more affected by the loosening of the joints under the weather should be closed up as well as possible.

I recall no special physical conditions requiring extraordinary precautions or unusual measures. The site is a particularly good one.

Charles P. Berkey
Geologist

New York, New York
September, 1926

MEMORANDUM

COVERING QUESTIONS ON THE CARVIN'S COVE DAM

Two questions have been raised by Mr. Moore touching certain construction problems affecting the foundation of the Carvin's Cove dam. One of these has to do with grouting and the method of carrying that work through. The other has to do with the effect of blasting and safe distances for such operations. The following comments are intended as reply to these questions, neither of which will require very extended discussion.

(1) The Question of Grouting.

Grouting of the seams or joints in the rock ledges forming the foundation was recommended simply as a means of checking leakage. The rock floor is sound, but it was noted that there are a good many joints. When the water is impounded so that there is pressure, then there is sure to be some leakage under any circumstances; but that can be reduced to a negligible amount by grouting.

This is a simple matter to talk about, but not so simple to execute in a very efficient way. It is quite impossible, as a matter of fact, to reach all of the joints without excessive care and expense, but the most open ones can be greatly improved. Pipes for should be set in drilled holes beneath the forward part of the dam from one end to the other. They should be distributed so as to reach the most open joints, and particularly where there are several. It is not necessary to set them very deep. Three or four to

ten feet ought to be sufficient if the pipe reaches the joints. Then after the foundation is started so that there is a capping over the rock, grout should be forced into these pipes and out into the joints under pressure. Simple gravity pressure will not accomplish much, but a pressure that forces the grout out into the crevices will accomplish a good deal. It is not very difficult to bring pressure of 200 lbs. to bear on it, and that is about what is usually done under these circumstances.

In places where the joints are more prominent than elsewhere, the pipes ought to be set more frequently or deeper. I cannot tell how many ought to be used. The grout will not flow through these joints very far. They are not very open, but some such method of plugging them will more than pay for itself in the general saving of leakage. The grouting can be finished early in the operation, and ends of the pipes ought to be covered up with the rest of the concrete as the dam is built up.

If there is leakage of consequence at any particular spot after the dam is in operation, that can be checked somewhat by dumping clay at the base of the dam so that it can be carried into the crevices with the circulation. There will be some tightening of the crevices, I think, in that manner anyway.

The rock is not soluble and the crevices will not have a tendency to widen. Unless the seepage, however, is reduced to very slow flow, the water might carry out such clogging material as is now lodged in them. This should be prevented by grouting and if that is done the clogging ought to continue, and the dam ought to

become tighter instead of more leaky with time.

(2) The Question of Blasting.

Mr. Moore says in his letter, "The question has been raised as to the proximity of blasting portions of the main seam of rock in the dam. Mr. Wysor is of the opinion that a distance of 150 feet from the main body of the dam would not be dangerous."

I am not absolutely sure that I have the form of the question right. I think it must mean something as follows: Can blasting operations be carried on on the same beds of rock that underlie the dam as near to the dam as 150 feet. The use of the word "main seam" in the original question leaves me a little confused. I suppose what was meant there was the main or principal beds or ledges of rock and that the essence of the question is whether blasting operations for structural material could be carried on near-by without damage to the foundations.

In my opinion any ordinary blasting operations can be carried on reasonably close. The distance ought to depend on the violence of the disturbances that are produced by blasting. Enormous charges such as are sometimes used in large operations might be objectionable at points as near as 150 feet, but I cannot conceive of any reason for using such violence in the operations at this place. Ordinary blasting for structural material in operations of this size ought not to cause any trouble if the operations are kept as far away as 150 feet. I do not think that they should come nearer.

I am assuming in saying this that the blasting would probably be done beyond the ends of the dam rather than below it. I would

not like to see quarrying operations carried on below the dam at all, but beyond the two ends I see no objection to it whatever.

If one opens up the rock floor below water level just in front of a dam, it sometimes exposes the joints more and encourages more leakage than the natural undisturbed floor. One should avoid that in all cases.

New York City
February 2, 1927

Charles P. Berkey
Geologist

APPENDIX C

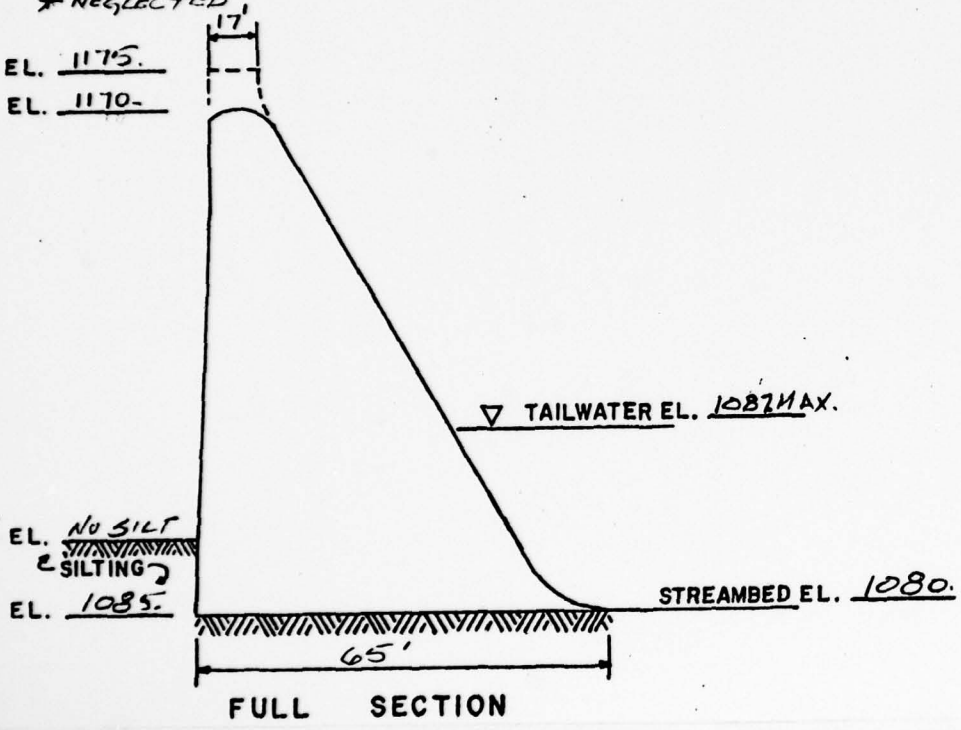
STRUCTURAL CALCULATIONS

GRAVITY DAM DESIGN
STABILITY ANALYSIS

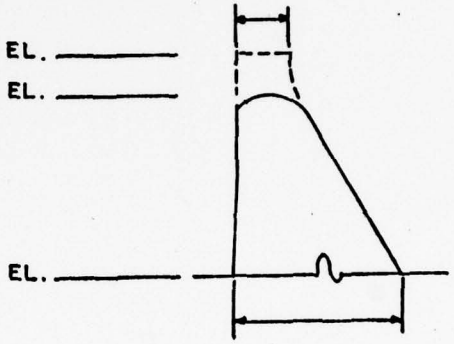
ANALYSIS DONE ON X FULL SECTION ___ PARTIAL SECTION
LOCATION OF SECTION CENTER OF SPILLWAY
ANALYSIS PREPARED BY *ERIC GENZ, CORPS OF ENGINEERS

LOADING CASE	ELEV. HEAD WATER	ELEV. TAIL WATER	ΣV	ΣH	ΣH/ΣV	LOCATION RESULTANT FROM TOE	% BASE IN COMPRESSION	FACTOR SAFETY SLIDING	FOUNDATION PRESSURE	
									TOE	HEEL
OPERATING CONDITIONS	1170.	0	324.K	226.K	.7	24'	100%	5.55	8.9 KSF	1.07 KSF
100 YR. FLOOD	1175.	0	314.K	253.K	.81	20.5'	94%	4.93	10.2 KSF	—
P.M.F.	1184.	1087.*	297.K	306.K	1.03	9'	42%	4.04	22 KSF	—

* NEGLECTED



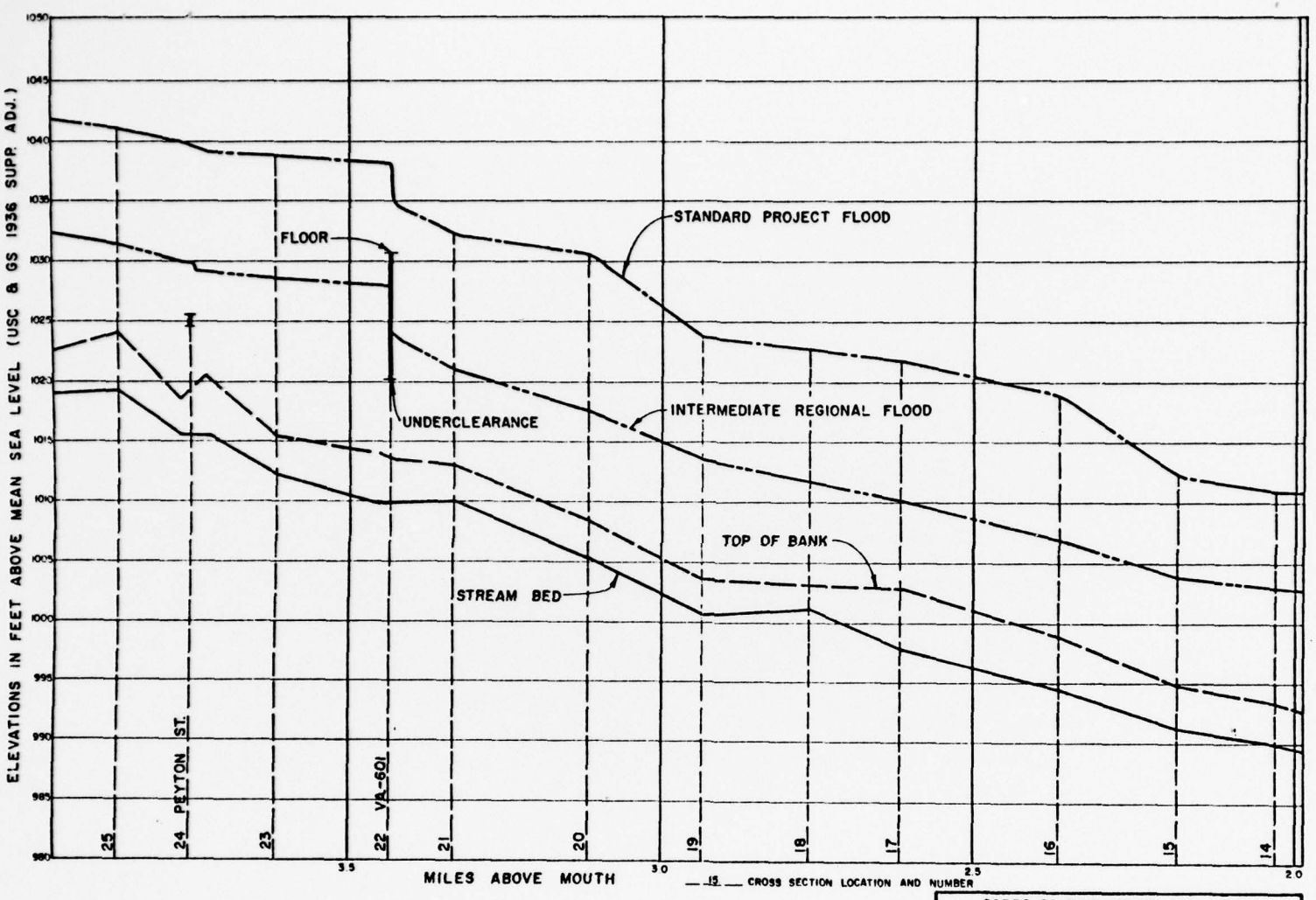
FULL SECTION



PARTIAL SECTION

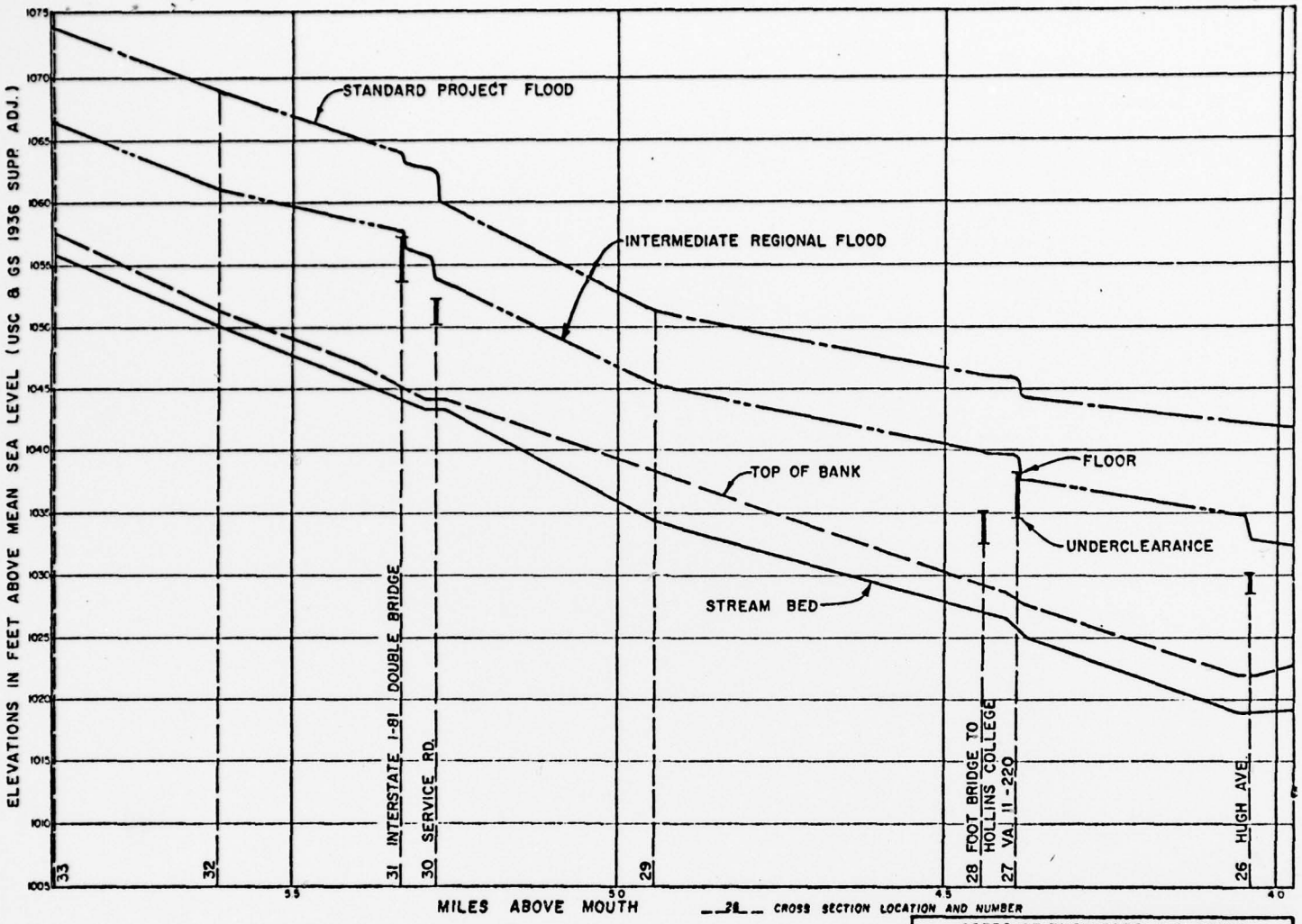
APPENDIX D

Hydraulic/Hydrology Profiles -
and Cross-Sections
Carvin Cove Creek



CORPS OF ENGINEERS, U.S. ARMY
WILMINGTON, NORTH CAROLINA DISTRICT

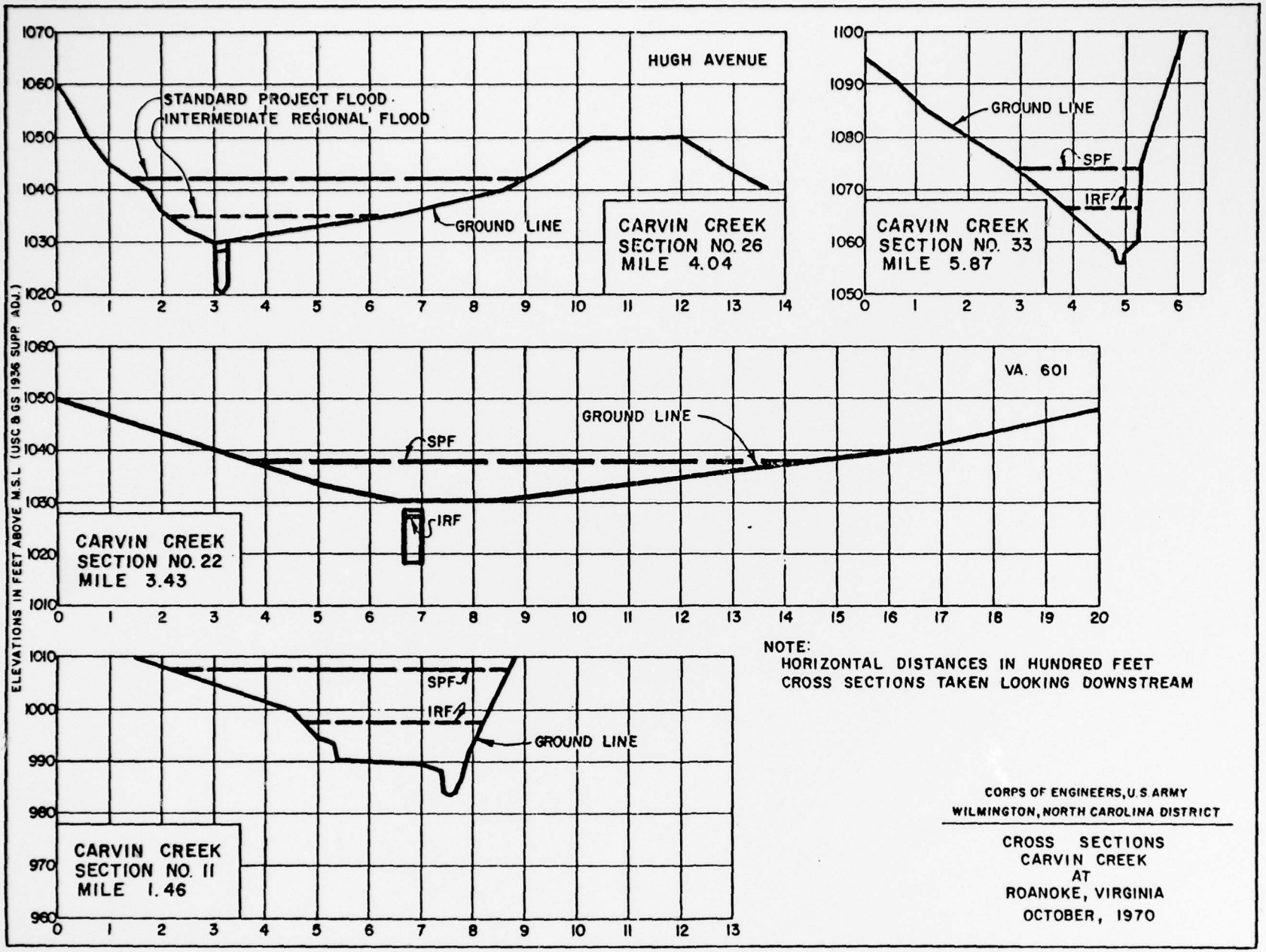
FLOOD PROFILES
CARVIN CREEK
ROANOKE, VIRGINIA
OCTOBER, 1970



CORPS OF ENGINEERS, U.S. ARMY
WILMINGTON, NORTH CAROLINA DISTRICT

FLOOD PROFILES
CARVIN CREEK
ROANOKE, VIRGINIA

OCTOBER, 1970



NOTE:
HORIZONTAL DISTANCES IN HUNDRED FEET
CROSS SECTIONS TAKEN LOOKING DOWNSTREAM

CORPS OF ENGINEERS, U.S. ARMY
WILMINGTON, NORTH CAROLINA DISTRICT

CROSS SECTIONS
CARVIN CREEK
AT
ROANOKE, VIRGINIA
OCTOBER, 1970