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NATIONAL DAM SAFETY PROGRAM. POTOMAC RIVER BASIN. WOODSTOCK (IN--ETC(U)
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1 OF 2
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POTOMAC RIVER BASIN

Name Of Dam: WOODSTOCK

Location: SHENANDOAH COUNTY, STATE OF VIRGINIA

Inventory Number: VA 17104

LEVEL II

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED FOR

NORFOLK DISTRICT CORPS OF ENGINEERS
803 FRONT STREET
NORFOLK, VIRGINIA 23510

AUGUST 1978

BY

MICHAEL BAKER, JR., INC.
BEAVER, PENNSYLVANIA 15009

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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

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(See reverse side)

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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.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

CONTENTS

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Woodstock
State: Virginia
County: Shenandoah
Stream: Little Stony Creek
Date of Inspection: 31 May 1978

BRIEF ASSESSMENT OF DAM

Woodstock Dam is a concrete gravity dam approximately 44 feet high and 388 feet long, owned and operated by the Town of Woodstock for water supply.

The visual inspections and review of available engineering data, made in May 1978, indicate no deficiencies requiring emergency attention. Hydrologic analysis indicates that the dam will be overtopped by 0.3 foot during the Probable Maximum Flood but will pass 50 percent of the Probable Maximum Flood. Structural calculations indicate that the dam does not meet the stability requirements of the Recommended Guidelines for Safety Inspection of Dams with respect to overturning for normal pool with an ice load and Probable Maximum Flood Conditions. Numerous small clear seeps at and beyond the toe of the spillway indicate that excessive uplift pressure may be present. In addition, the large (100 g.p.m.) clear leak downstream of the intake tower should be further investigated to determine if the leakage can be arrested or controlled.

Seepage control, tailwater during the Probable Maximum Flood, and detailed assessment of stability are items that should be further investigated by the owner. It is recommended that the owner install piezometers in the toe of the spillway to measure uplift pressures in the foundation bedrock.

Michael Baker, Jr., Inc.

Michael Baker, III, P.E.
Chairman of the Board and
Chief Executive Officer

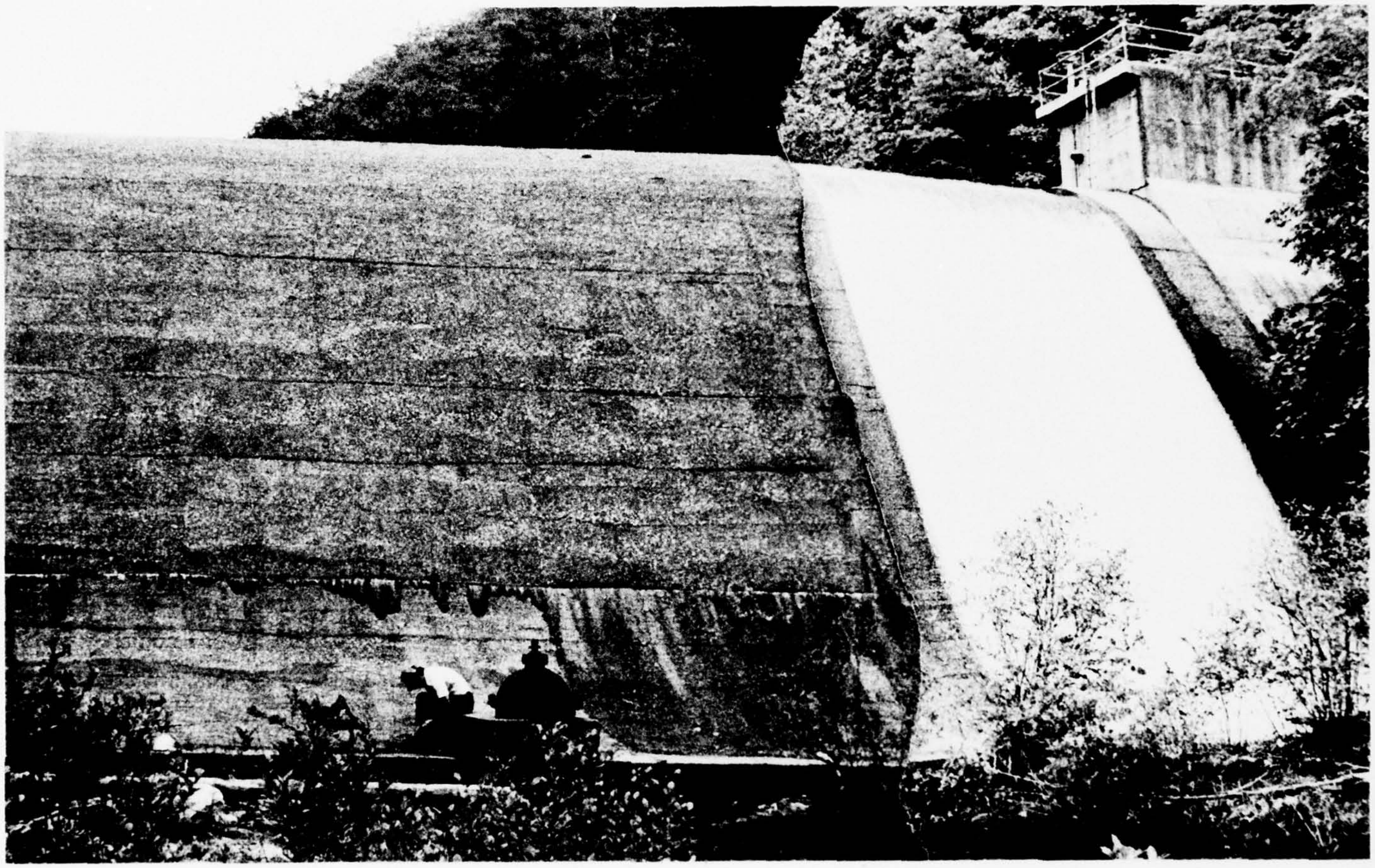
COMMONWEALTH OF VIRGINIA
MICHAEL BAKER III
NO. 3176
CERTIFIED PROFESSIONAL ENGINEER

APPROVED: Original signed by:
Douglas L. Haller

Douglas L. Haller
Colonel, Corps of Engineers
District Engineer

Date: AUG 16 1978

OVERALL VIEW OF DAM



OVERALL VIEW OF DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NAME OF DAM: WOODSTOCK ID# VA 17104

SECTION 1 - PROJECT INFORMATION

1.1 General

1.1.1 Authority: Public Law 92-367, 8 August 1972 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 is to conduct a Phase I inspection according to the Recommended Guidelines for Safety Inspection of Dams. The main responsibility is to expeditiously identify those dams which may be a potential hazard to human life or property.

1.2 Description of Project

1.2.1 Description of Dam and Appurtenances: Woodstock Dam consists of a concrete gravity section approximately 44 feet high and 388 feet long. The emergency spillway is a concrete gravity weir structure, 177 feet long with an 18 feet long recessed section that acts as a primary spillway. Although three inch foundation toe drains are shown on the original design drawings, none were observed. A line of grout holes 25 feet deep and at a 10 feet spacing was reportedly drilled in the cut-off at the heel of the spillway. The intake structure and outlet works are situated on the left non-overflow section. A 24 inch cast-iron pipe with gate valve on the downstream end is located near the center of the spillway. The discharge is controlled by manual operation of the 24 inch gate valve and a 12 inch cast-iron pipe in the intake structure. In addition, there are three sliding gate valves on the intake structure.

1.2.2 Location: Woodstock Dam is located on Little Stony Creek about four miles upstream of the Town of Columbia Furnace, Virginia. A number of summer cottages and cabins line the creek between the dam and Columbia Furnace. A Location Plan is included in this report.

1.2.3 Size Classification: The maximum height of the dam is 44 feet. The reservoir volume to the spillway crest is 52 acre-feet. Therefore, the dam is in the "intermediate" size category as defined by the Recommended Guidelines for Safety Inspection of Dams.

1.2.4 Hazard Classification: Due to the proximity of the Town of Columbia Furnace with a population of about 50, many lives could be lost in the event of failure of the dam. The presence of the summer cabins within a mile downstream of the dam creates a condition which adds to the consequences of a dam failure. Therefore, this dam is considered in the "high" hazard category as defined by Section 2.1.2 of Recommended Guidelines for Safety Inspection of Dams. The hazard classification used to categorize dams is a function of location only and has nothing to do with its stability or probability of failure.

1.2.5 Ownership: The dam is owned by the Town of Woodstock, Virginia.

1.2.6 Purpose of Dam: The dam is used for water supply for the town. The town is presently preparing to use the North Fork of the Shenandoah River for their primary water supply source at which time the Woodstock Reservoir will be used for emergency water supply.

1.2.7 Design and Construction History: The existing facility was designed for the owner by R. Stuart Royer and Associates of Richmond, Virginia and Poulton, Maher and Blake of Blacksburg, Virginia. The dam was built by Garrett, Moon and Poole Construction Company beginning in 1955 or 1956 and was completed in 1957. No known construction has been undertaken since the dam was built.

1.2.8 Normal Operational Procedures: The dam is normally operated with the reservoir level on the primary spillway crest at an elevation of 1255.0. The three slide gate intake levels of 1247.0, 1239.0 and 1231.0 are used to draw off water from near the surface of the reservoir as the water level drops. A 12 inch cast-iron pipe with an invert elevation of 1215.0 connects with an older eight inch cast-iron pipe which transports the water to the Town of Woodstock which is located over 10 miles east of the reservoir. Plate 1 shows this connection. No formal maintenance program exists for the dam other than the routine maintenance implemented by the town's water department to provide a functioning water supply source.

1.3 Pertinent Data

1.3.1 Drainage Area: The drainage area of Woodstock Dam is approximately 7.0 square miles.

1.3.2 Discharge at Dam Site: The maximum flow at the dam site through the spillway is not known.

Principal Spillway:
Pool level at emergency spillway crest . . . . 60 c.f.s.

Emergency Spillway:
Pool level at top of dam . . . 16,550 c.f.s.

1.3.3 Dam and Reservoir Data: Pertinent data on the dam and reservoir are shown in the following table:

TABLE 1.1 DAM AND RESERVOIR DATA

Item	Elevation feet M.S.L.	Reservoir Area acres	Reservoir Capacity Acre-feet	Reservoir Capacity Watershed inches(a)	Length feet
Top of dam	1263.5	6.0	102.0	0.27	1200
Maximum pool, design surcharge	1263.5	6.0	102.0	0.27	1200
Emergency spillway crest	1255.5	2.8	52.0	0.14	900
Principal spillway crest	1255.0	2.8	52.0	0.14	900
Streambed at center-line of dam	1222.0±	0	0	0	0

(a) Based on 7.0 square miles (approximated).

SECTION 2 - ENGINEERING DATA

2.1 Design: The design data reviewed included the following:

1) Photocopies of design plans done by R. Stuart Royer in 1955 and furnished by the Town of Woodstock. (Plates 1, 3 and 4).

2) As-built spillway profile elevations (Plate 2).

3) Specifications for the dam (Appendix V).

4) Concrete cylinder testing results (Appendix VI).

5) Letter of Transmittal from R. Stuart Royer dated 29 June 1978 (Appendix VIII).

6) Design Letter Report from Poulton, Maher and Blake dated 15 August 1955 (Appendix VIII).

All existing data has been filed with the Norfolk District for future reference.

2.2 Construction: The construction of the dam was completed by Garrett, Moon and Poole Construction Company in 1957. R. Stuart Royer inspected the construction which included concrete testing and reports by Froehling and Robertson. (Appendix VI). No photos of the construction were available.

2.3 Operation: The dam is operated and maintained by the Town of Woodstock as part of its water supply system. Records of water withdrawn from the reservoir for water supply are kept at the chlorinating house. No records of spillway flows are available. Three slide gates with intake levels of 1247.0, 1239.0 and 1231.0 are used to draw off water from near the surface of the reservoir as the water level drops.

2.4 Evaluation

2.4.1 Design: The design and as-built drawings provided by the Town of Woodstock were adequate for determining the structural stability of the dam.

2.4.2 Construction: An as-built drawing of the spillway profile was provided by the designer. Concrete cylinder tests showed adequate concrete strength.

2.4.3 Operation: The operational procedures are adequate for the water supply facilities.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

3.1.1 General: The dam and its appurtenant structures were found to be in good overall condition at the time of inspection. The problems noted during the visual inspection of the dam do not require immediate remedial treatment but the problems should be corrected as part of the maintenance program. Noteworthy deficiencies observed are described briefly in the following paragraphs. The complete visual inspection check list is given in Appendix III.

3.1.2 Dam: Generally, all concrete structures are in good condition. Minor spalling and calcite staining are present primarily at or near the non-overflow sections.

Although the foundation rock was grouted during construction, the most notable defect in the dam is the active clear seepage at a number of locations including:

1) Through vertical joints in the spillway between the bucket area and seven to eight feet above the bucket (more than one g.p.m.). (Photos 1 through 3).

2) Through horizontal joints in the spillway near the primary spillway section (more than one g.p.m.). (Photos 1 through 3).

3) Through shale bedrock at the toe of the spillway at the end of the right non-overflow section (one g.p.m.).

4) Through rock at the toe of the spillway 24 feet left of the right non-overflow section (one g.p.m.). (Photo 4).

5) Through soil 36 feet downstream of the toe of the spillway (same elevation as the toe) in the abutment at Station 1+90.[1] (one g.p.m.) (Photo 5).

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[1] Stations are shown on Plate 2.

6) At the toe of the non-overflow section between Stations 2+80 and 2+90[1] (100 g.p.m.). (Photo 6). This area coincides with the location of the 12 inch cast-iron pipe outletting from the intake tower. No serious erosion was observed.

All seepage was measured with a stop watch and calibrated plastic bucket.

Plate 4 is a sketch of the measured dimensions of the dam. It shows that the bottom of the spillway is at the same elevation from end to end and does not follow the abutment slopes as indicated on the original plans. It does, however, correspond to the as-built foundation elevations shown on Plate 2.

3.1.3 Appurtenant Structures: Spillway, see comments on dam paragraph 3.2.1.

3.1.4 Reservoir Area: No serious shoreline or gully erosion was observed.

3.1.5 Downstream Channel: The channel immediately downstream of the spillway is composed of shale bedrock with an abundance of boulders.

3.2 Evaluation

3.2.1 Dam: The concrete in the spillway and non-overflow sections is in good condition and requires no immediate repair. The clear seepage described above should be assessed as to its effect on the stability of the spillway structure. The hydrostatic uplift should be measured by piezometers placed into the foundation rock through the toe of the spillway. The estimated 100 g.p.m. clear leak downstream of the intake structure should be investigated to determine if the clear leak represents seepage through shale bedrock or a damaged 12 inch concrete pipe. Through correspondence with R. Stuart Royer and Ássociates, the designer, the clear leak ceases when the reservoir is lowered to half of its height. The spring issuing from the ground 36 feet downstream of the toe of the spillway is an indication that hydrostatic uplift pressure equals a positive head above the toe of the spillway. Further investigation is required.

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[1]Stations are shown on Plate 2.

3.2.2 Appurtenant Structures: Further investigation is required to determine if the 12 inch outlet pipe is leaking or if the clear seepage at this point originates in the backfill for the pipe.

3.2.3 Reservoir Area: Does not require further investigation.

3.2.4 Downstream Channel: Does not require further investigation.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures: Operational procedures are generally discussed in paragraphs 1.2.8 and 2.3. The normal reservoir elevation of 1255.0 is controlled by the primary spillway overflow.

There is no formal written procedure for emergency downstream evacuation in the event of impending catastrophe. The dam is visited by maintenance personnel from the Town of Woodstock. These personnel should be instructed to watch for distressed conditions. In addition, the U.S. Forest Service has inspected Woodstock Dam (see Appendix IX).

Rapid emergency drawdown is controlled through the 24 inch cast-iron gate valve located on the downstream toe of the spillway at Station 2+29.[1]

4.2 Maintenance of Dam: Because of its water supply function, the dam is frequently visited by maintenance personnel. Some patching and finishing of small areas of the spillway were noticed during the field inspection of the dam. However, the good overall condition of the concrete spillway indicates that to date vigilant maintenance has not been necessary for the dam.

4.3 Maintenance of Operating Facilities: Maintenance personnel of the Town of Woodstock frequently operate the slide gates on the intake tower, especially during low runoff periods when the reservoir level drops. The frequency of opening the 24 inch gate valve is not known. However, visual examination of the operating nut, stuffing box, bonnet, pipe plug and body indicates no excessive corrosion or neglect.

Photo 7 shows a clear leak through a crack in the right wall of the intake tower. Although this defect does not directly cause a structural failure, it would interfere with repair of the intake structure and gates if such repairs were necessary.

4.4 Warning System: At the present time, there is no warning system or evacuation plan in operation. It is recommended that a formal emergency procedure be prepared and prominently displayed and furnished to all operating personnel. This should include:

1) How to operate the dam during an emergency.

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[1] Stations are shown on Plate 2.

2) Who to notify, including public officials, in case evacuation from the downstream area is necessary.

3) Procedures for evaluating inflow during periods of emergency operation.

4.5 <u>Evaluation</u>: Presently, maintenance of the dam by water department personnel of the Town of Woodstock and periodic inspections by the U.S. Forest Service is considered acceptable. However, the water department may have less incentive to continue a maintenance program when the major source of town water becomes the North Fork of the Shenandoah River relegating the reservoir to an auxiliary storage facility. Dam inspections should continue in any case.

SECTION 5 - HYDRAULIC/HYDROLOGIC DATA

5.1 Design: The Woodstock Dam was designed by R. Stuart Royer and Associates of Richmond, Virginia, for the Town of Woodstock. The design spillway discharge of 7160 c.f.s. was based upon Meyer's formula with an assumed design spillway width of 140 feet. The constructed spillway width is 177 feet. The constructed spillway is an ogee section with the emergency crest at elevation 1255.5 feet and an 18 feet wide notch at elevation 1255.0 for normal flows. This notch acts as a primary spillway.

The capacity of the spillway at the top of dam elevation of 1263.5 is 16,550 c.f.s. The hazard class and size of this dam require evaluation of the Probable Maximum Flood (P.M.F.) as the spillway design flood. Design computations of this type are not available; therefore, it was necessary to determine preliminary estimates of the P.M.F.

5.2 Hydrologic Records: No records of the lake levels were available. However, town officials said that the reservoir was "drained" four to five times in the last 10 years.

5.3 Flood Experience: Although the dam has existed for many years, there is no recorded flood data.

5.4 Flood Potential: Design features were established by using the flood estimates noted in paragraph 5.1.

5.5 Reservoir Regulation: Pertinent dam and reservoir data are shown in Table 1.1, paragraph 1.3.3.

Except for withdrawal for water supply, regulation of flow is not necessary. The ungated spillway passes all inflow with some retention time due to storage during floods.

No outlet discharge capacity, reservoir area and storage capacity, and hydrograph and routing determinations were provided by the owner or designer.

5.6 Overtopping Potential: The probable rise in the reservoir and other pertinent information on reservoir performance in various hydrographs is shown in the following table:

TABLE 5.1 RESERVOIR PERFORMANCE

Item	Normal	Flood 100 year(a)	Flood 1/2 P.M.F.	Flood P.M.F.(b
Peak flow, c.f.s.				
Inflow	-	1520	8910	17,820
Outflow	-	1481	8900	17,759
Peak elev., ft. M.S.L.	1255.0	1257.3	1261.0	1263.8
Emergency Spillway				
Depth of flow, ft.	-	1.8	5.5	8.3
Avg. velocity, f.p.s.	-	4.8	9.1	11.7
Non-overflow Section(c)				
Depth of flow, ft.	-	-	-	0.3
Avg. velocity, f.p.s.	-	-	-	11.0
Tailwater elev., ft. M.S.L.	-	-	-	-

(a) One percent chance of occurrence based upon six hour rainfall.
(b) P.M.F., as determined by S.C.S. Hydrology Handbook, routing using HEC-1 by C.O.E.
(c) Dam overtopping during the P.M.F. only.

5.7 Reservoir Emptying Potential: The 24 inch cast-iron pipe and gate valve at the bottom of the spillway will permit withdrawal of about 93 c.f.s. with the reservoir level at the spillway crest and essentially dewater the reservoir in about 12 hours.

5.8 Evaluation: Hydrologic and hydraulic determinations of the project were prepared by Michael Baker, Jr., Inc. as approximations of the P.M.F. The spillway will not pass the P.M.F. as required by Corps of Engineers criteria, and therefore is considered inadequate. The spillway is of sufficient size to pass approximately 93 percent of the P.M.F. value without overtopping the dam.

It should be indicated that conclusions pertain to present day conditions, and that the effect of future development on the hydrology has not been considered.

SECTION 6 - DAM STABILITY

6.1 Foundations and Abutments: The foundation is composed of calcareous shale with a measured strike of S.4.5°W. and dip of 63°SE. Limestone was observed outcropping on the abutments and valley slopes. Discussions with the designer indicated that additional excavation was necessary to place the foundation on bedrock.

6.2 Stability Analysis

6.2.1 Visual Observations: During the inspection of the concrete dam structure, no unusual vertical or horizontal movements and no unusual structural cracking were found. However, there was clear seepage in the vertical joints extending eight feet above the top of the spillway toe. In addition, clear seepage was observed surfacing about 36 feet downstream from the toe of the concrete spillway and at the toe.

6.2.2 Design Data: Since the original designer did not provide their computations, a stability check was performed on a full cross section through the dam (see Appendix VII). The stability computations were made in accordance with Gravity Dam Design, U.S. Army Corps of Engineers, Manual EM 1110-2-2200 25 September 1958 (including change 2) and ETL 1110-2-184, 25 February 1974.

Stability analyses were completed for four cases:

I Water level at normal pool (elevation 1255.5) - with ice load.

II Water level at normal pool with ice load plus additional uplift pressure due to downstream clear seepage.

III P.M.F. condition (elevation 1263.8), - no ice load - tailwater assumed at 1225.0.

IIIA P.M.F. condition (elevation 1263.8) - no ice load - partial section.

Case II was considered because of the clear seepage observed 36 feet downstream of the spillway bucket. Uplift pressure at the toe of the analyzed section was increased proportionally. Case III was the P.M.F. condition with an assumed tailwater elevation of 1225.0 or five feet above the bottom of the spillway. Lack of cross sections and downstream gradients precluded the calculations of tailwater in the Phase I investigation. The tailwater necessary to move the resultant force to the middle one-third of the spillway foundation was calculated to be 13 feet for the P.M.F. case.

All four cases are similar in the following respects:

1) The resultant force does not fall within the middle one-third of the base.

2) The factor of safety against sliding is more than adequate (where $\phi = 50°$ and S = 100 p.s.i. for the shale foundation and $\phi = 45°$ and S = 450 p.s.i. for the concrete).

However, the ratio $\frac{\Sigma H}{\Sigma V}$ increases from an acceptable 0.65 in Case I to unacceptable values of 0.79 in Case II, 0.89 in Case III, and 0.88 in Case IIIA.

No calculations from the designer were provided. However, R. Stuart Royer submitted a structural drawing by Poulton, Maher and Blake. This drawing shows plotted "action lines" for the spillway section for various loading conditions. The "action line" for the condition "Weight and Flood Pressure and 67 Percent Uplift" corresponds to a flood level at elevation 1260.5. The "action line" coincides with the middle one-third boundary. The additional three feet of flood pressure used in Case III of the stability calculations for this report causes the resultant force to move downstream of the middle one-third. For Cases I, II and IIIA, the resultant is outside but near the middle one-third boundary.

6.2.3 Operating Records: The structure has no instrumentation for indicating movements, deflections or other related data, which might record the dam's experience under prior maximum loading conditions.

6.2.4 Post-Construction Changes: No unusual post-construction changes have been made in the watershed area which would substantially affect the water level.

6.2.5 Seismic Stability: The dam is located in Zone 2; therefore, the dam is considered to have no hazard from earthquakes provided static stability conditions are satisfactory and conventional safety margins exist.

6.3 Evaluation: Because the dam does not meet all the stability requirements according to EM 1110-2-2200, the actual uplift pressures below the spillway should be determined by the installation of piezometers. In addition, a detailed hydraulic analysis should be made to determine the actual tailwater during the P.M.F.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment: There are findings, as a result of this inspection, from which an unsafe assessment can be rendered. Clear seepage, which may indicate excessive uplift pressure, was found. The spillway is considered adequate to pass approximately one-half of the P.M.F. without overtopping the dam. However, the P.M.F. will overtop the dam by 0.3 foot.

In addition, the dam does not meet the stability criteria required by the *Recommended Guidelines for Safety Inspection of Dams* for normal pool with an ice load and during the P.M.F.

The town provided photocopies of design drawings. The designer provided some design and as-built information. The information was adequate to conduct a Phase I evaluation.

Although significant clear seepage was noted and the dam at normal pool does not meet stability requirements, visual inspection showed no evidence of existing or past spillway movement. However, the owner should determine actual uplift pressure and the cause of the 100 g.p.m. clear leak at the left abutment as soon as possible.

7.2 Recommended Remedial Measures: The inspection revealed certain items of rehabilitation or other work which should be incorporated with dam maintenance during the next two years by the owner. These are:

1) Determination of actual seepage pressures below the dam. This can be obtained with piezometers.

2) Determination of the cause of the 100 g.p.m. clear leak in the left downstream abutment and repair of the leak.

3) Further analysis should be made of the marginal calculated stability of the spillway. This includes a determination of the tailwater elevation during the P.M.F.

4) Patching the clear leak in the intake tower above the highest slide gate by maintenance personnel during the next scheduled maintenance visit. No remedial treatment of the clear leaking vertical joints in the spillway is

necessary because the loss of water and deterioration are minimal at the present time. However, the condition of the concrete should be inspected periodically.

5) Further investigating the possibility of enlarging the spillway to pass the P.M.F. without overtopping the dam.

6) Controlling the clear seepage through the dam foundations and abutments with relief drains.

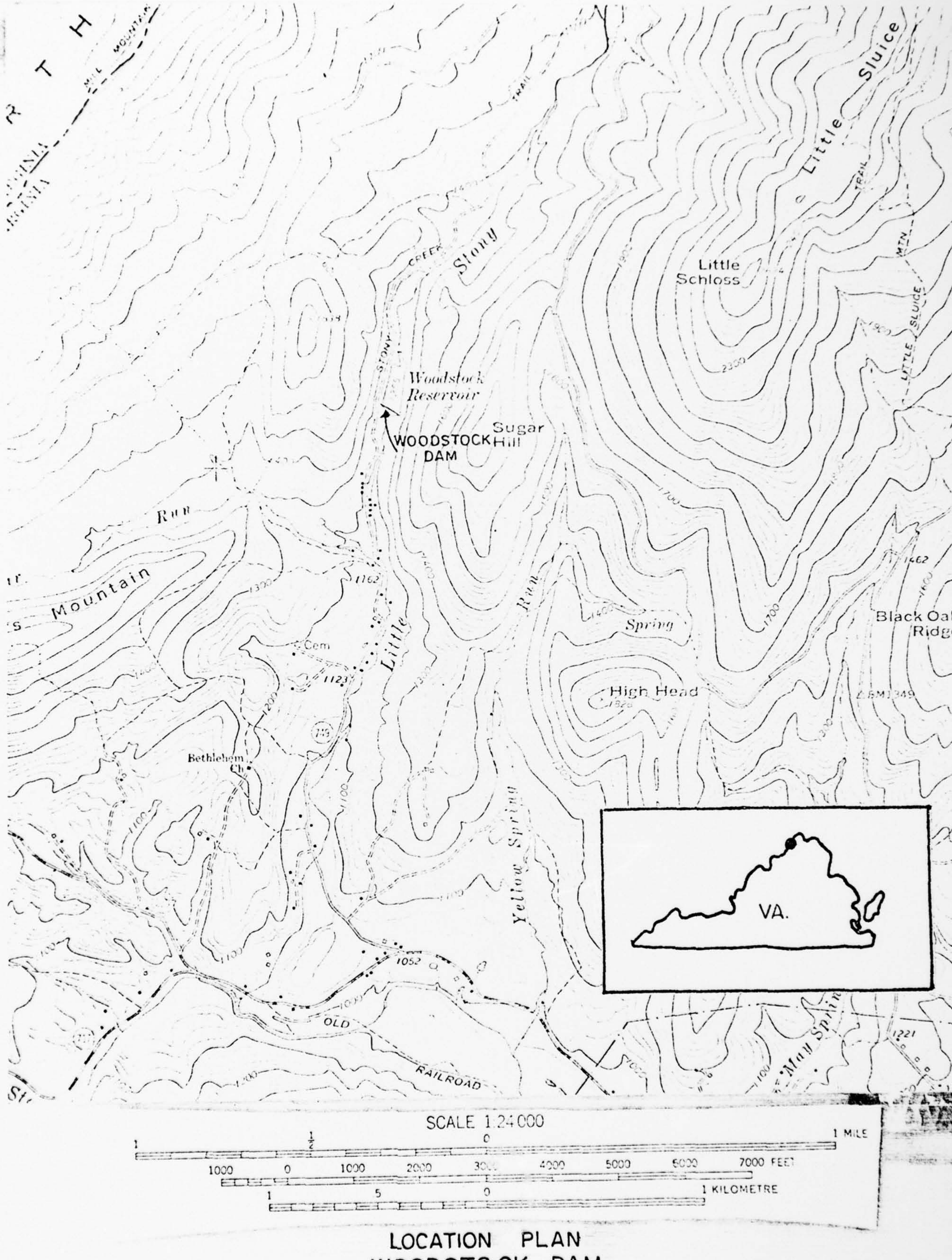
7) Providing a formal inspection schedule for Woodstock Dam when it is no longer the major source of water for the Town of Woodstock.

APPENDIX I

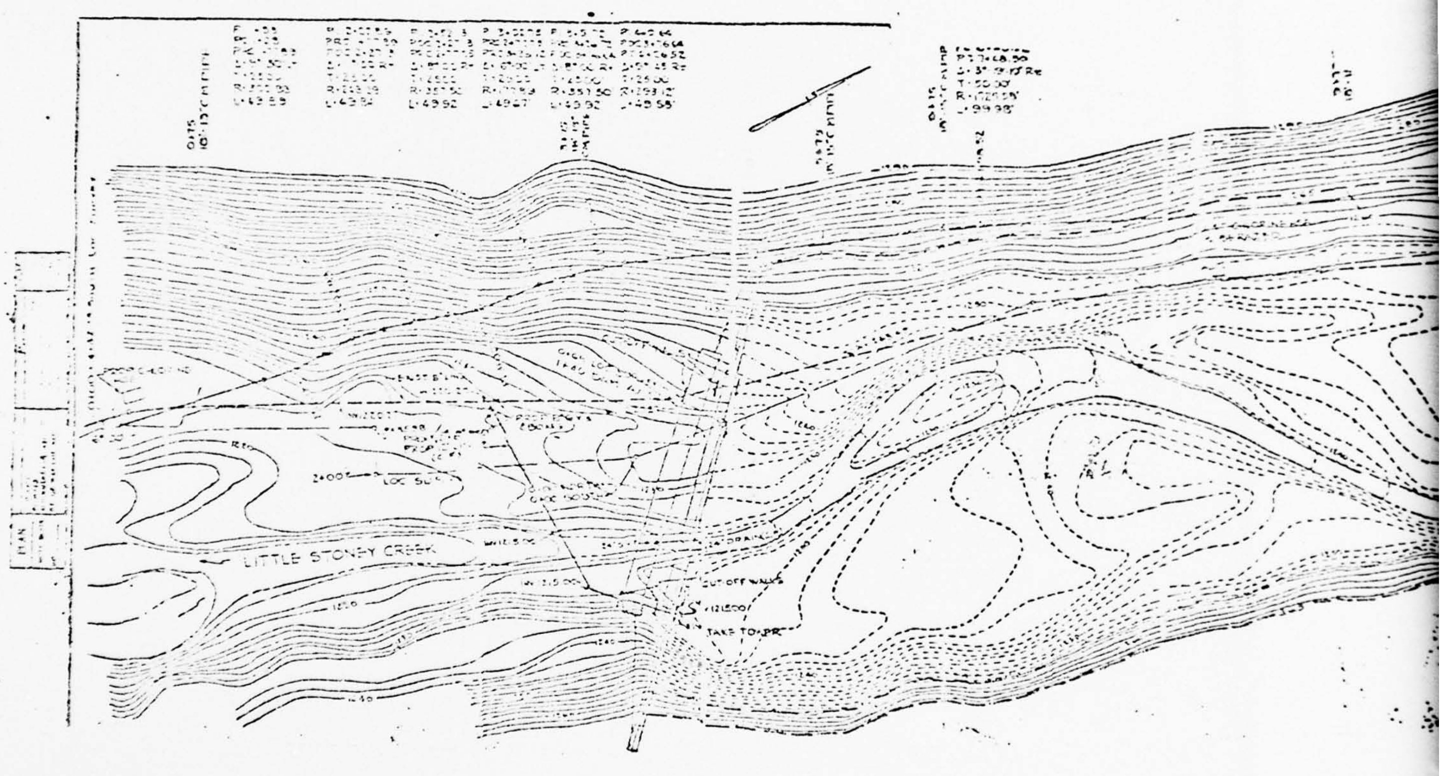
PLATES

CONTENTS

NAME OF DAM: WOODSTOCK



LOCATION PLAN
WOODSTOCK DAM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CUT OFF WALLS
TAKE TO PR

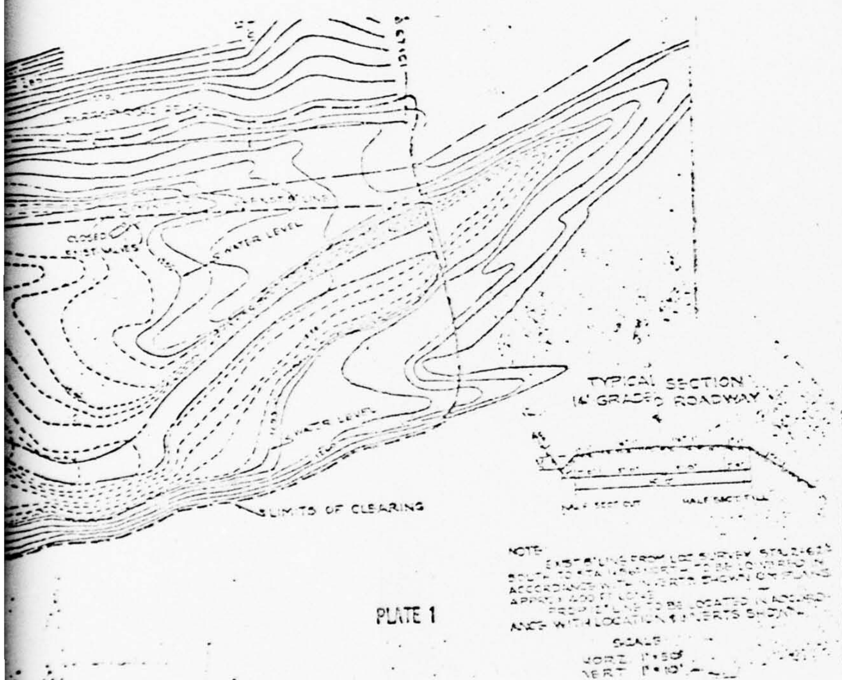
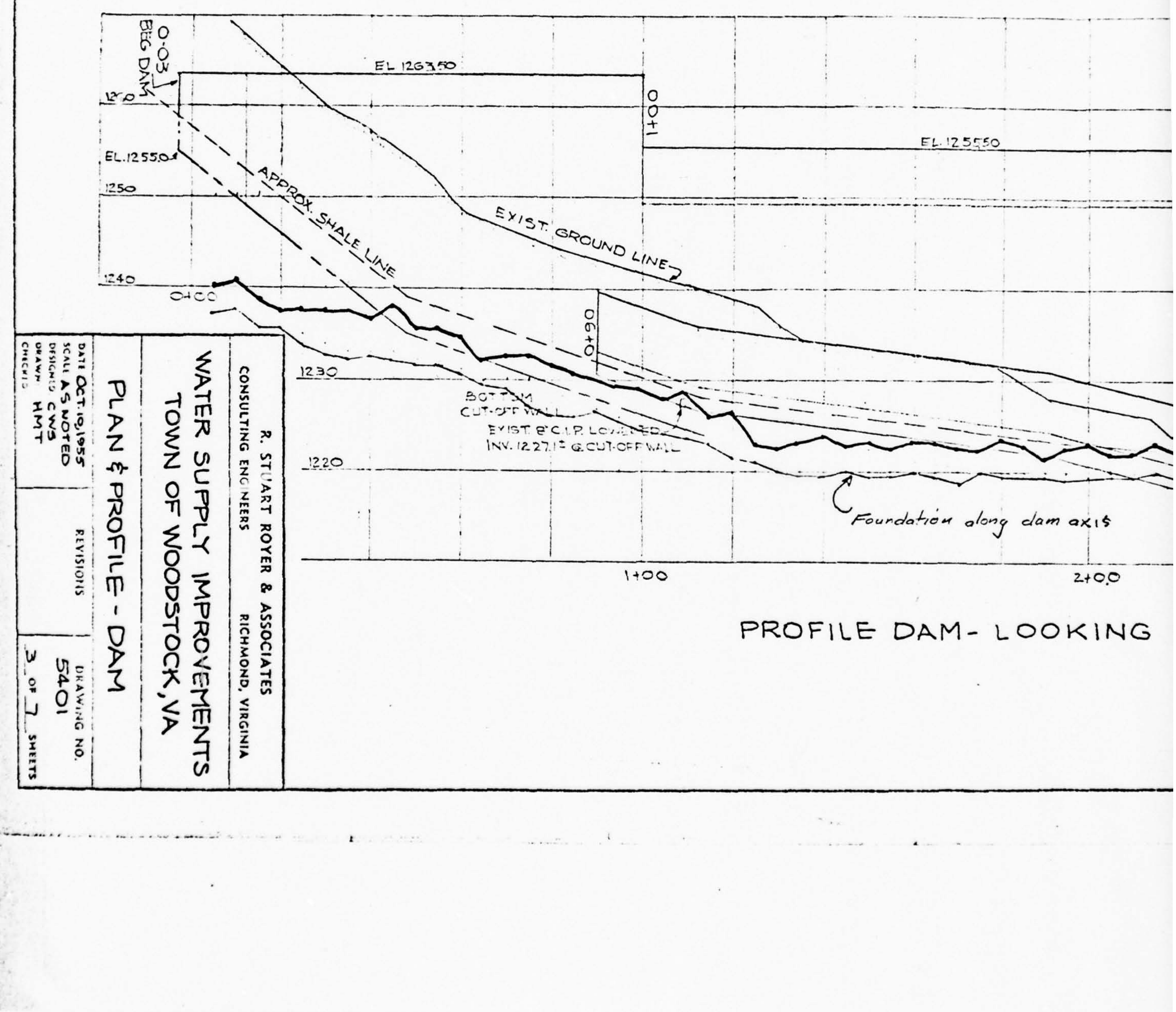

WATER LEVEL
WATER LEVEL
LIMITS OF CLEARING
TYPICAL SECTION
14' GRADED ROADWAY
NOTE:
ANCE WITH LOCATION & INVERTS SHOWN
SCALE

PLATE 1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1270
1+00
EL. 1255.0
EL. 1255.50
1250
APPROX. SHALE LINE
EXIST. GROUND LINE
1240
0+00
0+60
1230
BOTTOM CUT-OFF WALL
EXIST. 8" C.I.P. LOWERED
INV. 1227.1± @ CUT-OFF WALL
1220
Foundation along dam axis
1+00
2+00
PROFILE DAM- LOOKING
R. STUART ROYER & ASSOCIATES
CONSULTING ENGINEERS
RICHMOND, VIRGINIA
WATER SUPPLY IMPROVEMENTS
TOWN OF WOODSTOCK, VA
PLAN & PROFILE - DAM
DATE OCT. 10, 1955
SCALE AS NOTED
DESIGNED CWS
DRAWN HMT
CHECKED
REVISIONS
DRAWING NO.
5401
3 OF 7 SHEETS

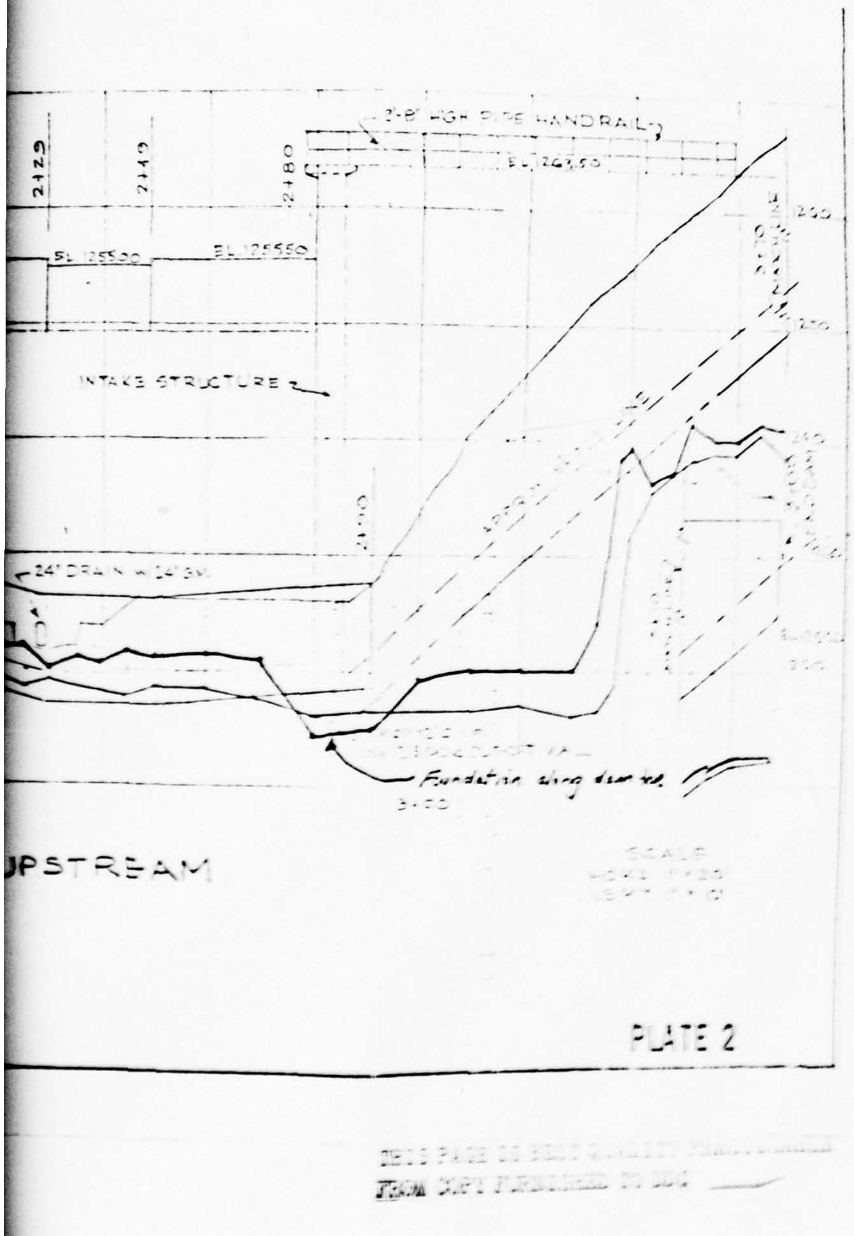

2'-8" HIGH PIPE HANDRAIL
EL 1263.50
2+29
2+49
2+80
EL 1255.00
EL 1255.50
INTAKE STRUCTURE
24" DRAIN W/24" G.V.
Foundation along dam axis
3+00
UPSTREAM
SCALE

PLATE 2

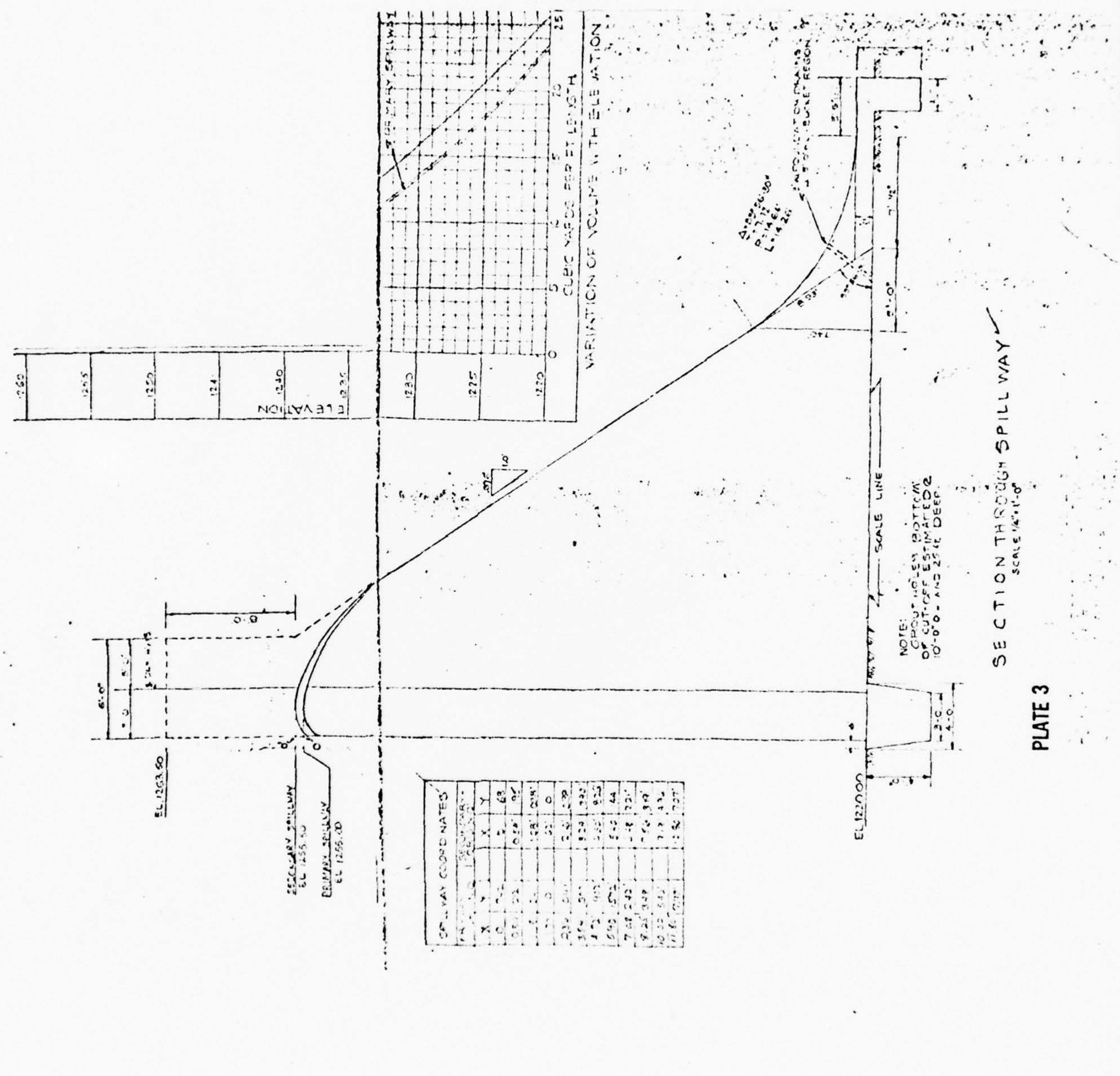
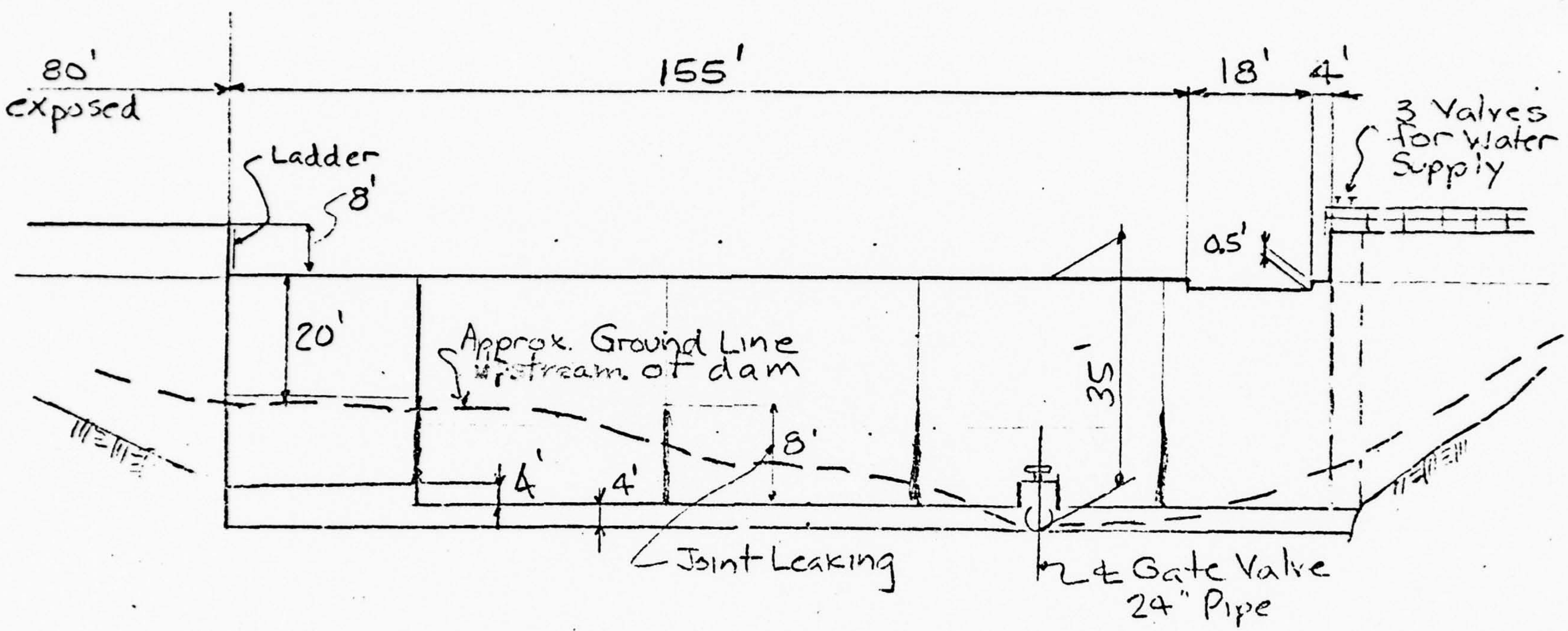

SECTION THROUGH SPILL WAY
VARIATION OF VOLUME WITH ELEVATION
ELEVATION
SCALE LINE
EL 1263.50
EL 1210.00
SPILLWAY COORDINATES

PLATE 3



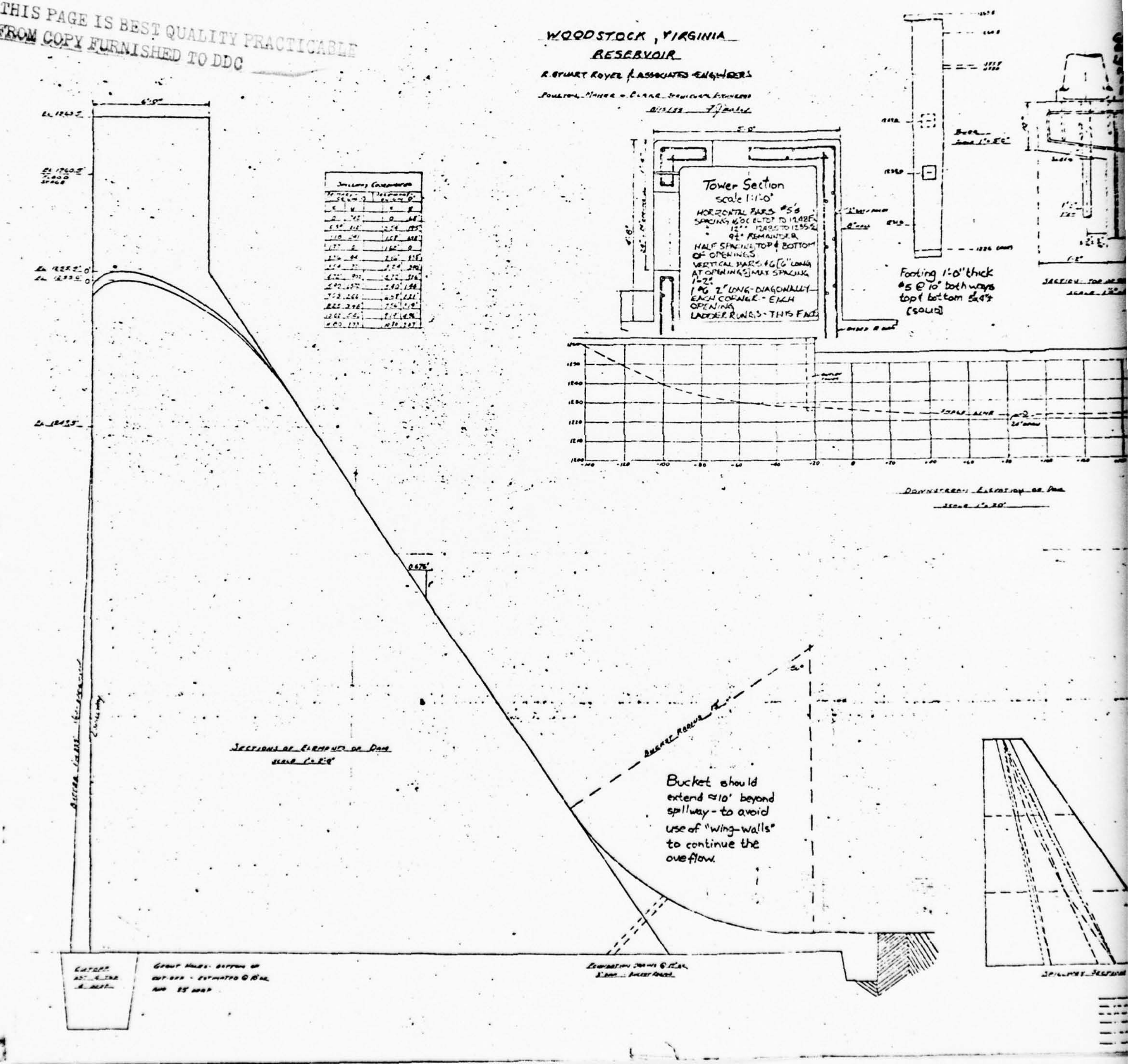
WOODSTOCK - ELEVATION OF DOWNSTREAM FACE

(AS SKETCHED FROM FIELD MEASUREMENTS)

NOT TO SCALE

June 1978

PLATE 4


WOODSTOCK, VIRGINIA
RESERVOIR
R. STUART ROYER & ASSOCIATES ENGINEERS
Tower Section
scale 1':1'0"
HORIZONTAL BARS #5's
HALF SPACING TOP & BOTTOM OF OPENINGS
LADDER RUNGS - THIS FACE
Footing 1'-0" thick
#5 @ 10" both ways
top & bottom
(SOLID)
DOWNSTREAM ELEVATION OF DAM
SECTIONS OF ELEMENTS OF DAM
BUCKET RADIUS
Bucket should extend ≈10' beyond spillway - to avoid use of "wing-walls" to continue the oveflow.
SPILLWAY SECTION

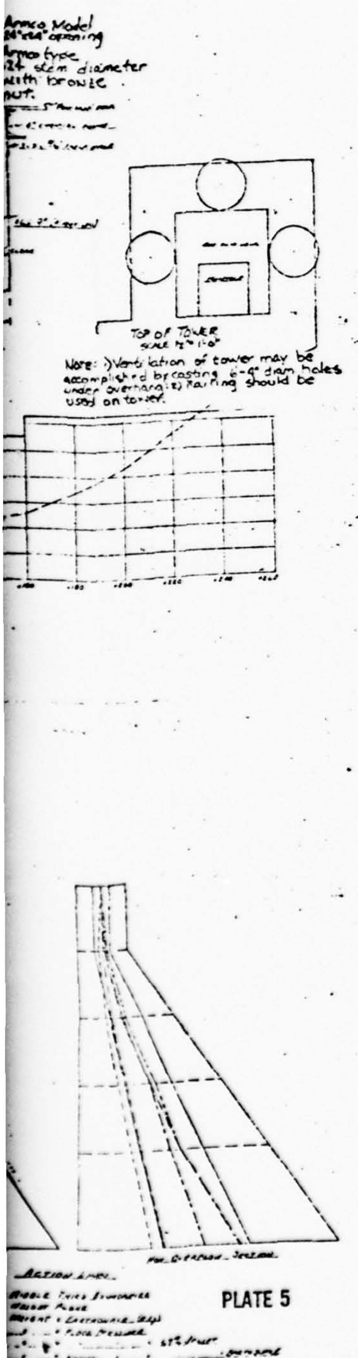

Armco Model
24"x24" opening
Armco type
2 1/4" stem diameter
with bronze
nut.
TOP OF TOWER
Note: 1) Ventilation of tower may be accomplished by casting 6-4" diam holes under overhang. 2) Railing should be used on tower.

PLATE 5

2

TEST BORING LOG

T.H. #1	
GR. EL. [illegible]	
DEPTH	SOIL STATUS
0'0" – 1'0"	TOP SOIL
	MIXTURE OF BOULDERS AND CLAY BOULDERS ARE SANDSTONE SOME CORE [illegible]
6'8"	SHALE APPROX. 75% CORE RECOVERY
26'9"	BORING TERMINATED

T.H. #2	
GR. EL. 1227.6	
DEPTH	SOIL STATUS
0'0" – 1'0"	TOP SOIL
	MIXTURE OF BOULDERS AND SOME CLAY
4'[illegible]"	SHALE STREAKED WITH CALCITE APPROX. 90% CORE RECOVERY
24'7"	BORING TERMINATED

T.H. #3	
GR. EL. 1233.1	
DEPTH	SOIL STATUS
0'0"	MIXTURE OF BOULDERS AND SOME CLAY
7'4"	SHALE
11'3"	CLAY SEAM
11'9"	SHALE APPROX. 90% CORE RECOVERY
27'4"	BORING TERMINATED

T.H. #4	
GR. EL. 12[illegible]	
DEPTH	SOIL STATUS
0'0"	TOPSOIL
4'0"	BOULDERS SOME CLAY
5'0"	SHALE APPROX. 90% CORE RECOVERY
25'5"	BORING TERMINATED

T.H. #5	
GR. EL. 1252.8	
DEPTH	SOIL STATUS
0'0"	BOULDERS SOME CLAY BOULDERS FROM 3" TO 3'
14'0"	SHALE APPROX. 40% CORE RECOVERY CORES BADLY BROKEN
34'0"	BORING TERMINATED ALL WASH WATER LOST

T.H. #6	
GR. EL. 1239.6	
DEPTH	SOIL STATUS
0'0"	BOULDERS AND CLAY APPROX. 10% CORE RECOVERY IN DRILLING BOULDERS
12'9"	SHALE APPROX. 35% CORE RECOVERY
32'0"	BORING TERMINATED ALL WASH WATER LOST

T.H. #7	
GR. EL. 1254.5	
DEPTH	SOIL STATUS
0'0"	BOULDERS AND CLAY SOME CORE RECOVERY IN BOULDERS
15'6"	SHALE APPROX. 70% CORE RECOVERY
35'6"	BORING TERM. ALL WASH WATER LOST

VERTICAL SCALE: 1" = 6'0"

APPENDIX II

PHOTOGRAPHS

CONTENTS

Note: Photographs were taken 31 May 1978.

NAME OF DAM: WOODSTOCK

WOODSTOCK DAM

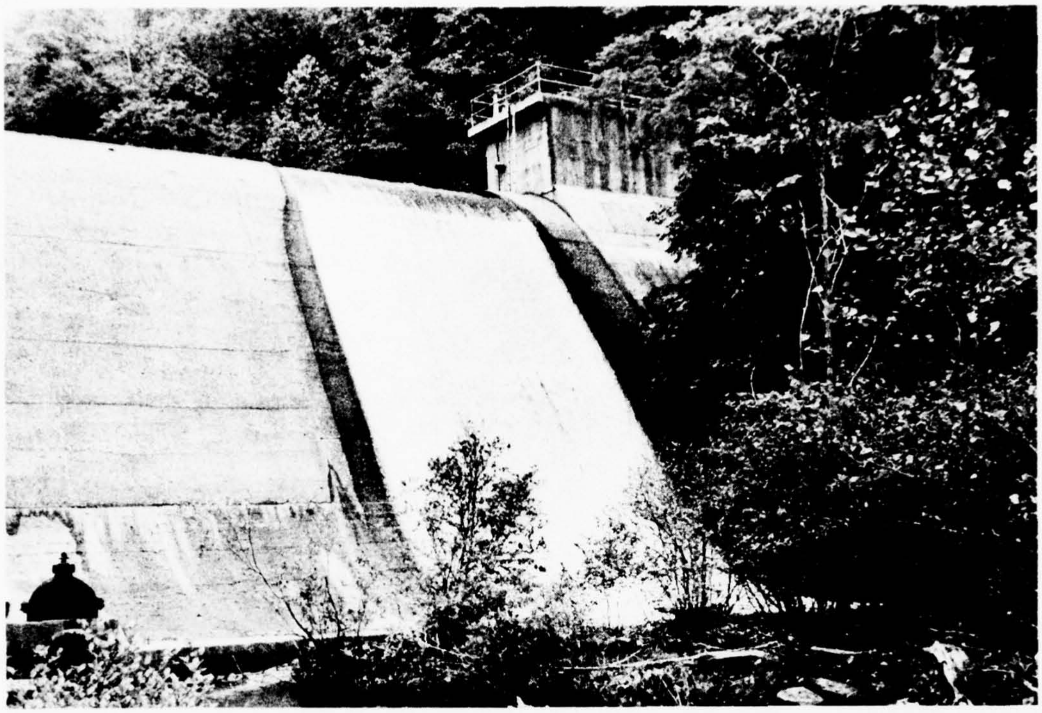


PHOTO 1
Left Downstream Face of Dam

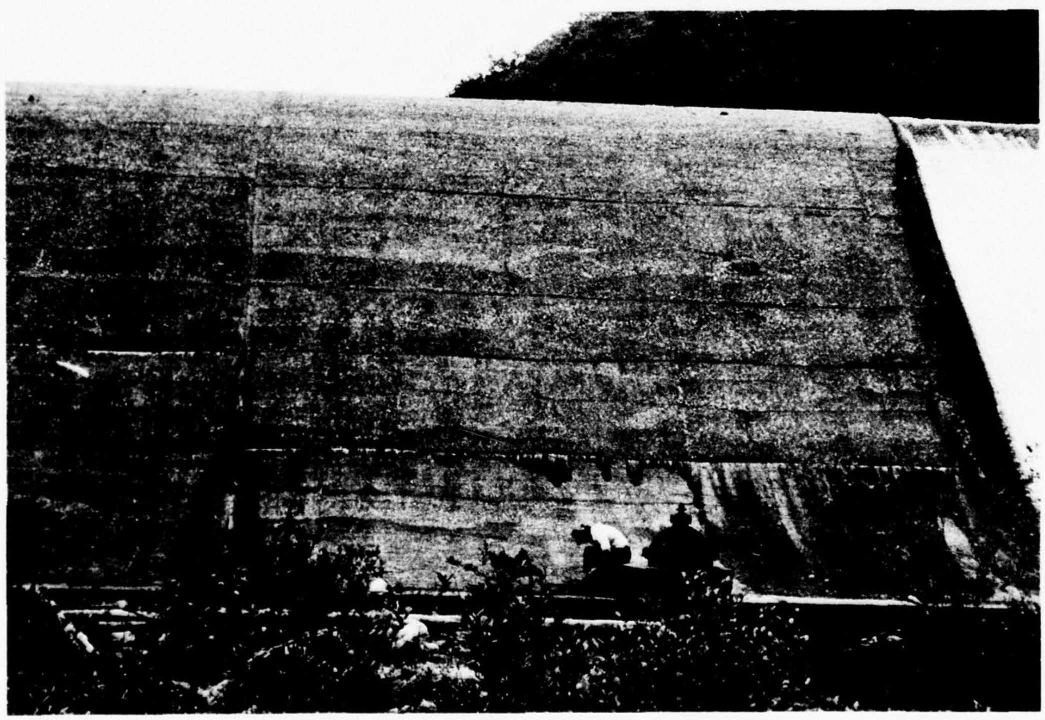


PHOTO 2

Center Downstream Face of Dam

WOODSTOCK DAM

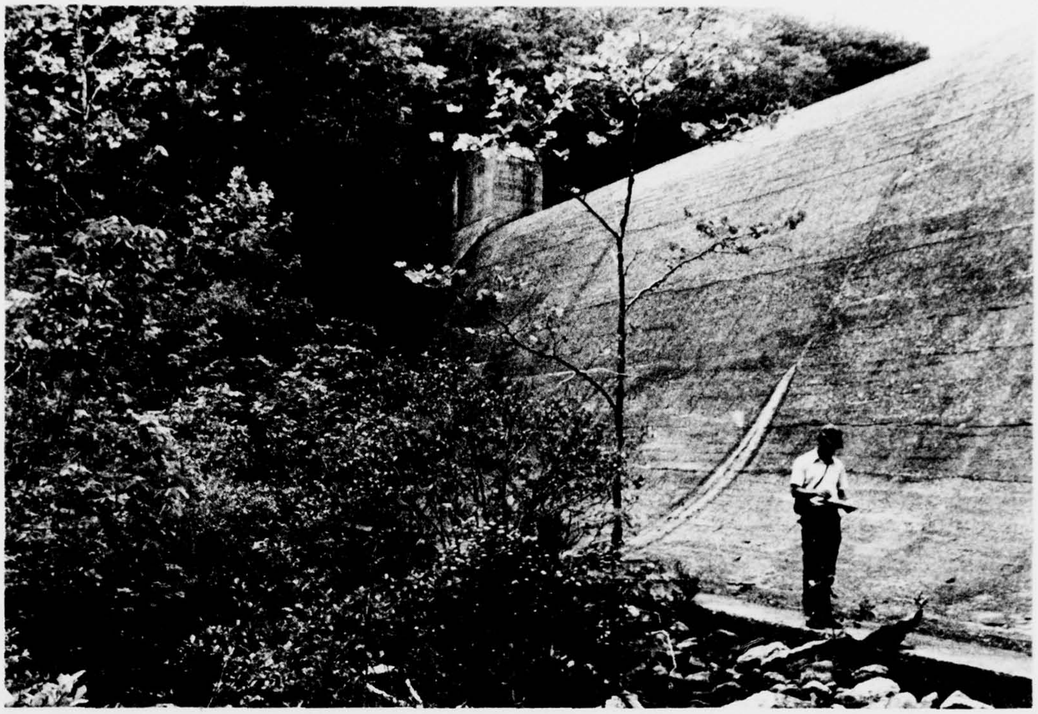


PHOTO 3
Right Downstream Face of Dam

PHOTO 4

Clear Seepage at End of Spillway Bucket

WOODSTOCK DAM

PHOTO 5
Clear Seepage 36′ Downstream of Spillway

PHOTO 6

Clear Seepage at Toe of Spillway Below Intake Tower (appx. 100 g.p.m.)

WOODSTOCK DAM

PHOTO 7
Leak in Right Wall of Intake Tower

APPENDIX III

CHECK LIST - VISUAL INSPECTION

Check List
Visual Inspection
Phase 1

Name Dam Woodstock County Shenandoah State Virginia Coordinates Lat. 3855.1 Long. 7839.4

Date Inspection 31 May 1978 Weather Clear & Cloudy, Showers Temperature 85°F.

Pool Elevation at Time of Inspection 1255.3 M.S.L. Tailwater at Time of Inspection 1220.0 M.S.L.

Inspection Personnel:

MICHAEL BAKER, JR., INC.:	VIRGINIA WATER CONTROL BOARD:
J. Dziubek	T. Mizell
D. Greenwood	
J. Thompson	

J. Dziubek Recorder

CONCRETE/MASONRY DAMS

Woodstock

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
	All of the vertical construction joints of the main dam are leaking clear water starting eight feet above the top of the bucket area.	The joints are in fair condition.
STRUCTURE TO ABUTMENT/ EMBANKMENT JUNCTIONS	Good, but the ground is covered with thick humus and leaves. Clear leakage at bottom of both abutments was noted. No erosion channels were noted.	
DRAINS	There are no drains in the concrete part of the dam except the 24 inch pipe which drains the entire reservoir. The valve control appears in good condition.	The town officials said they drain the reservoir about once a year.
	None were noted in field. However, they are noted in specifications and plans.	Design drawings show foundation drains on 15 feet centers.
WATER PASSAGES	There was very minor erosion of the shale under the concrete at the 18 feet wide primary spillway of the main dam section.	Good condition
FOUNDATION	There was no damage to the downstream toe concrete and little or no undermining for the entire length of the main dam. Calcareous shale outcropping at end of ogee. Altitude S.4.5°W. 63°SE. Limestone higher on abutments and outcropping on sides of mountain valley. The toe of the entire ogee section is El. 1220. The plans show a varying toe elevation from 1230 to 1220. Discussions with the designer revealed that additional excavation was necessary to place the foundaton on bedrock.	Good condition

CONCRETE/MASONRY DAMS

Woodstock

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	The concrete surface at the top of the emergency spillway crest is honeycombed. Six square feet have been previously patched. The aggregate is exposed on a large part of the surface. Surface cracks are few and minor. 1) Few cracks observed. Those seen were hairline cracks except for "chip" on downstream right side of overflow section. 2) Calcite staining at a horizontal joint on right and left abutments non-overflow section. 3) Calcite staining is higher at left non-overflow section than on the spillway.	Good condition
STRUCTURAL CRACKING	No structural cracking was observed on the main face of the dam and the abutment walls.	Good condition
VERTICAL AND HORIZONTAL ALIGNMENT	No vertical or horizontal movements were observed. No visual displacement or bowing were observed.	Good condition
MINOLITH JOINTS	The joints were tight and in good condition.	Good condition
CONSTRUCTION JOINTS	The horizontal construction joints were visible and in very good condition. The vertical joints have minor spalling at the surface where they are leaking. Clear leakage at vertical joints at tangent to Bucket Region.	Good condition
ROCK ANCHORS	Three by six inch steel plates with a spacing of six feet (possibly bearing for rock anchors) were observed at the spillway toe.	

EMBANKMENT

Woodstock

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None noted	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None noted	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	No erosion channels--red clay apparently dumped on left abutment at end of dam--might have experienced erosion in past. None at ground contact on downstream face of concrete sections.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Concrete crest--no observed misalignment.	
RIPRAP FAILURES	No riprap around the structure. Downstream channel is bedrock.	

EMBANKMENT

Woodstock

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	No separations noted. Much dead leaf and forest litter cover.	
ANY NOTICEABLE SEEPAGE	There are four major areas of seepage: 1. At toe of weir at end of right non-overflow section (one g.p.m.). 2. At toe of weir 24 feet left of right non-overflow section (one g.p.m.). 3. Thirty-six feet downstream of toe of weir. (El. of toe of ogee). Midpoint of spillway (one g.p.m.). 4. At toe of weir at end of left non-overflow section (100 g.p.m.). This coincides with position of a 12 inch cast-iron pipe from intake tower on plans.	Piezometers should be installed to determine the magnitude of uplift pressure below the dam.
STAFF GAGE AND RECORDER	Gage chained to outlet tower.	
DRAINS	None noted, although three inch drains on 15 feet centers in bucket section of the spillway were required by specifications and shown on plans.	Drains will be necessary if uplift pressure needs to be reduced.

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	None observed	
INTAKE STRUCTURE	There is a clear leak through a horizontal crack above highest sluice gate. It was noticed when the water level in the chamber was lowered as the maintenance worker opened the bottom gate.	The clear leak should be sealed because it prevents access to the bottom of the intake tower.
OUTLET STRUCTURE	The 24 inch gate valve on the downstream side appeared in good condition. No corrosion or excessive rust was observed.	
OUTLET CHANNEL	Rock channel at downstream end of ogee section. No evidence of excessive erosion or scour.	
EMERGENCY GATE	24 inch gate valve - See "OUTLET STRUCTURE".	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	The control section for the overflow is closer to the intake structure than the original design drawings show. The width of the entire overflow section is 177 feet - three feet less than shown on the plans.	
APPROACH CHANNEL	This is a concrete gravity spillway and has no approach channel.	
DISCHARGE CHANNEL	Bedrock (shale) forms the major part of the downstream area. No scouring or undercutting of the bucket area was observed.	
BRIDGE AND PIERS	Not Applicable	

Woodstock

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None observed in field.	
OBSERVATION WELLS	None observed in field or indicated in plans.	Piezometers on observation wells should be installed to measure the uplift pressure below the gravity section.
WEIRS	None observed in field or indicated in plans.	
PIEZOMETERS	None observed in field or indicated in plans.	Piezometers on observation wells should be installed to measure the uplift pressure below the gravity section.
OTHER		

RESERVOIR

Woodstock

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Steep wooded slopes (45 percent with limestone rock outcrops. No major areas of erosion or sliding were observed.	
SEDIMENTATION	Thirty soundings made from spillway crest. Depth to bottom is a maximum of 35 feet, indicating very little sedimentation.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	There is an overgrowth of trees downstream of ogee section The rock channel is 12 to 15 feet wide and flat. Very little erosion was noted in field.	
SLOPES	Not Applicable	
APPROXIMATE NO. OF HOMES AND POPULATION	Thirty homes, three road bridges and six to ten smaller bridges for access to summer cottages were counted.	

APPENDIX IV

CHECK LIST - ENGINEERING DATA

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

Woodstock

ITEM	REMARKS
PLAN OF DAM	Copy of drawings obtained.
REGIONAL VICINITY MAP	On plans of dam--designer: R. Stuart Royer & Asso., 15 W. Cary Street, Richmond, VA and Poulton, Maher and Blake, Blacksburg, VA
CONSTRUCTION HISTORY	1955 - Date of plans 1957-58 - Date of construction.
TYPICAL SECTIONS OF DAM	Rock embedment equals eight feet. Soil embedment is 10 to 15 feet. Design engineer indicated rock over excavation was necessary at dam centerline.
HYDROLOGIC/HYDRAULIC DATA	Ogee (1255.5) Primary weir (1255.0) Non-overflow (1263.5)
OUTLETS - PLAN	- Part of spillway plan.
- DETAILS	- Cut-off wall nine by six feet.
- CONSTRAINTS	- Three (3) 24 inch gates with elevations of 1247, 1239 and 1231.
- DISCHARGE RATINGS	- None on plans.
RAINFALL/RESERVOIR RECORDS	

Woodstock

ITEM	REMARKS
DESIGN REPORTS	None available
GEOLOGY REPORTS	Seven test borings Shale--depth is 4.6 feet to 15.5 feet (recovery approximately 75 to 90 percent) Soil--Boulders & clay (TH #5 = 40 percent) Reportedly done but not received.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Some available from designer.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Test borings Concrete cylinders taken.
POST-CONSTRUCTION SURVEYS OF DAM	Bidders price--part of specifications.
BORROW SOURCES	None, dam is concrete gravity.

Woodstock

ITEM	REMARKS
MONITORING SYSTEMS	Not indicated on plans.
MODIFICATIONS	Not indicated on plans.
HIGH POOL RECORDS	Not available
POST-CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Town Engineer, R. Stuart Royer has inspected the dam (no reports). Last inspection was two weeks ago. According to Town Manager, studies on adequacy were done by Royer in 1975, 1977 and in May 1978.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None Known
MAINTENANCE OPERATION RECORDS	None

Woodstock

ITEM		REMARKS
SPILLWAY PLAN		
	SECTIONS	Bucket
	DETAILS	Shape of ogee generally conforms to the plans.
OPERATING EQUIPMENT PLANS & DETAILS		
		Reservoir drained four to five times in last ten years.
		Three inch foundation - 15 feet center to center in bucket.

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: Approximately 7.0 square miles

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 1255.5 (17.3 acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 1263.5 (345 acre-feet)

ELEVATION MAXIMUM DESIGN POOL: 1263.5

ELEVATION TOP DAM: 1263.5

CREST: Free overfall concrete ogee shape

a. Elevation 1255.5 emergency, 1255.0 primary
b. Type Concrete ogee
c. Width Not applicable
d. Length 180 feet
e. Location Spillover Entire length of dam
f. Number and Type of Gates Three (3) 24 inch square slide gates for water supply inlets. Handwheel control.

OUTLET WORKS: Bucket at bottom of ogee

a. Type Rectangular weir and 24 inch pipe and gate valve
b. Location Spillway, approximately center of dam
c. Entrance inverts 1222
d. Exit inverts 1222
e. Emergency draindown facilities one(1) 24 inch

HYDROMETEOROLOGICAL GAGES: None

a. Type
b. Location
c. Records

MAXIMUM NON-DAMAGING DISCHARGE Unknown

APPENDIX V

ORIGINAL CONSTRUCTION SPECIFICATIONS

DESCRIPTION

TOWN OF WOODSTOCK, VIRGINIA

The work contemplated includes the construction of a concrete gravity dam with outlet tower, reservoir, clearing and grubbing, relocation of existing 8" water line, new ~~8"~~ 12" water line from outlet tower and connect with existing 8" water line, roadway relocation, chlorinator building and chlorination equipment, razing present chlorine building, all complete as per plans and specifications as prepared by R. Stuart Royer & Associates, dated September, 1955.

Scope of Work:

The work contemplated includes the construction of a concrete gravity dam with outlet tower, reservoir, clearing and grubbing, relocation of existing 8" water line, new 8" water line from outlet tower and connect with existing 8" water line, roadway relocation, chlorinator building and chlorination equipment, razing present chlorine building, all complete as per plans and specifications.

Present Facilities:

The present dam, reservoir, chlorine house and pipe line are to be maintained in service until such time as the present line is relocated, and the new chlorine building and chlorinator installed. The contractor shall conduct his work so as to avoid damage to the present facilities and interuptions of services. Any damage to existing facilities shall be immediately corrected by the contractor at his own cost and expense.

Clearing & Grubbing

(a) Reservoir and Dam Area:

The reservoir area to be inundated and the dam site shall be cleared and grubbed of all vegetation below contour elevation 1265, but not to extend beyond the present dam as indicated on the plans. The establishment of the clearing line shall be the responsibility of the contractor.

All marketable timber in the reservoir, dam, roadway and spillway areas will be removed by the ~~National Park Service~~ Town of Woodstock. Laps and stumps remaining shall be disposed of by the contractor.

All vegetation, including grass, forest mould, leaves, broomstraw, underbrush, laps, windfalls, stumps, unmarketable timber, trees, and other forms of vegetation or foreign matter shall be removed from the reservoir and dam areas and burned on site or in a manner approved by the Engineer. After burning, ashes and remaining residue shall be buried with 6" earth cover or removed from the site.

All stumps shall be grubbed out, including all exposed roots. Excess excavated earth material may be used as fill in stump holes. Fills shall be leveled off to level of adjacent ground surface.

All salvageable material, other than as retained by the National Park Service, shall become the property of the Contractor and shall be removed from the site, otherwise shall be burned.

It is the intent of the specifications, that on completion of the clearing and grubbing of the reservoir area, that the area be devoid of all organic matter which may become decomposed and create offensive taste and odor, and that the bottom and slopes present a clean earth, clay sand or rock surface, suitable for impounding a water supply for the Town.

(b) Roadway

The contractor shall clear and grub within the working limits of the proposed roadway. Clearing and grubbing shall comply with the requirements specified for clearing and grubbing within the reservoir and dam area except that all trees, stumps and underbrush shall be cut-off at ground laps, and forest mould, leaves allowed to remain in place to be subsequently removed on excavation.

(c) Spillway

Clearing of spillway area shall conform to the requirements specified on roadways.

Coffer-Dams and Unwatering:

The contractor shall construct and maintain all necessary coffer - dams, channels, flumes and/or other temporary diversion and protective works; shall furnish all material required therefor; and shall furnish, install, maintain and operate all necessary pumping and other equipment for unwatering the various parts of the work, and for maintaining the foundation, cut-off trenches and other parts of the work free from water as required for constructing each part of the work. After having served their purpose, all cofferdams and other temporary protective works shall be removed.

Preparation of Rock Foundation for Concrete:

The surfaces of all rock foundations upon or against which concrete is to be placed shall be preparedto provide adequate bond between the rock and the concrete by roughtening and cleaning the rock surfaces. All loose rock fragments, spalls, dirt, gravel, grout and other objectionable matters shall be removed from the rock surfaces. Immediately before placing concrete upon or against any rock surface, the surface shall be thoroughly cleaned by the use of stiff brooms, hammers, picks, jets of water and air and other effective means satisfactory to the contracting officer. After cleaning and before concrete is placed, all water shall be removed from depressions so as to permit thorough inspection and proper bond of concrete with the foundation rock.

Pressure Grouting

Grout holes shall be drilled into the rock foundations of the cut-off walls. It is expected that the depth of holes required will not exceed 25'. The minimum diameter of each hole shall be as directed. Each grout hole shall be protected from becoming clogged or obstructed by being capped or otherwise protected until the hole is grouted.

Metal pipes for grout connections shall be set on the concrete cut off walls, spaced 10 feet apart. Grout pipes set in concrete shall end not less than 1" inside the finished surfaces of the concrete, and recesses shall be provided in the concrete to be filled with mortar after the grouting is completed. The size of the grout pipe for each hole will be determined to meet the requirements of the drilling and grouting equipment used. The spaces between grout pipes and the rock or concrete into which they are inserted shall be carefully calked with oakum or other suitable material to prevent entry of concrete or other materials prior to grouting.

Grout shall be forced into each drilled grout hole and grout connection under pressure of up to 100 pounds per square inch as required. For ordinary grouting work, the grout shall be composed of cement and water with a water cement ratio of from 1 to 2. Before pressure grouting is begun, all grout holes shall be thoroughly washed out with clean water by inserting a pipe into the hole and introducing the wash water into the bottom of the hole. No grout hole or grout connection shall be grouted, except with permission, until all concrete required within a radius of 50 feet is placed and set.

Materials

1. Portland cement shall comply with the "Standard Specifications for Portland Cement", (ASTM Designation: C-150), or the "Tentative Specifications for Air-Entraining Portland Cement", (ASTM Designation: C-175), and shall be Type IV if available. Otherwise, Type II shall be used.

2. Concrete Aggregates

(a) Concrete aggregates shall conform to the "Standard Specifications for Concrete Aggregates" (ASTM Designation: C-33) or to the "Standard Specifications for Lightweight Aggregates for Concrete" (ASTM Designation: C-130), except that aggregates failing to meet these specifications but which have been shown by special test or actual service to produce concrete of the required quality may be used where authorized by the engineer.

(b) The maximum size of the aggregate shall not be larger than one-fifth of the narrowest dimension between forms of the member for which the concrete is to be used nor larger than three-fourths of the minimum clear spacing between reinforcing bars.

(c) Cobble rock may be included in the concrete mixtures for mass concrete. Such cobble rock shall be sound, hard, clean gravel or broken rock of such size as will pass through a screen having 6-inch square openings and be retained on a screen having 2-3/4-inch square or 3-inch round openings. The suitability of cobble rock will be determined by the contracting officer. The amount of such cobble rock to be used shall be based on producing the most economical concrete of the required strength, and, insofar as practicable, utilizing the entire yield of the natural deposit or quarry from which the gravel or broken rock is obtained.

The use of cobble rock will not be required or permitted where the concrete is reinforced, or in any part of the structure where the least dimension is less than 30 inches.

3. Water

The water used in concrete shall be reasonably clean and free from objectionable quantities of silt, organic matter, alkali, salts, and other impurities.

4. Metal Reinforcement

(a) Reinforcing bars shall conform to the requirements of the "Standard Specifications for Minimum Requirements for the Deformations of Deformed Steel Bars for Concrete Reinforcement" (ASTM Designation: A 305) and of the "Standard Specifications for Billet-Steel Bars for Concrete Reinforcement" (ASTM Designation: A 15), or "Standard Specifications for Rail-Steel Bars for Concrete Reinforcement" (ASTM Designation: A 16), or "Standard Specifications for Axle-Steel Bars for Concrete Reinforcement" (ASTM Designation: A 160).

(b) Structural steel shall conform to the requirements of the "Standard Specifications for Steel for Bridges and Buildings" (ASTM Designation: A 7).

5. Storage of Materials

Cement and aggregates shall be stored at the work in such a manner as to prevent deterioration or intrusion of foreign matter. Any material which has deteriorated or which has been damaged shall not be used for concrete.

Concrete

1. Concrete Quality

(a) The water-cement ratio for concrete exposed to freezing and thawing shall not exceed 6 gallons per sack of portland cement. For the interior of the dam the water-cement ratio may be as high as 7 gallons per sack, with the exception that the minimum 28 day compressive strength of the concrete shall be 3000 pounds per square inch. Excessive overmixing, requiring additions of water to preserve the required concrete consistency, will not be permitted. Surface water contained in the aggregate must be included as part of the mixing water in computing the water content.

2. Concrete Proportions and Consistency

(a) The proportions of aggregate to cement for any concrete shall be such as to provide a mixture which will work readily into the corners and angles of the forms and around reinforcement with the method of placing employed on the work, but without permitting the materials to segregate or excess free water to collect on the surface. The combined aggregates shall be of such composition of sizes that when separated on the No. 4 standard sieve, the weight passing the sieve (fine aggregate) shall be not less than 30% nor more than 50% of the total unless otherwise required by the engineer.

(b) The methods of measuring concrete materials shall be such that the proportions can be accurately controlled and easily checked at any time during the work. Measurement of materials for ready-mixed concrete shall conform to the "Standard Specifications for Ready-Mixed Concrete" (ASTM Designation: C 94).

3. Tests on Concrete

(a) During the progress of the work compression test specimens shall be made and cured in accordance with the "Standard Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Field" (ASTM Designation: C 31). Not less than three specimens shall be made for each test, nor less than one test for each 250 cu. yd. of concrete of each class. Specimens shall be cured under laboratory conditions except that when, in the opinion of the engineer, there is a possibility of the surrounding air temperature falling below 40 deg. F., he may require additional specimens to be cured under job conditions.

(b) Specimens shall be tested in accordance with the "Standard Method of Test for Compressive Strength of Molded Concrete Cylinders" (ASTM Designation: C 39).

(c) The Standard age of test shall be 28 days, but 7-day tests may be used provided that the relation between the 7- and 28-day strengths of the concrete is established by test for the materials and proportions used.

(d) If the average strength of the laboratory control cylinders for any portion of the structure falls below the compressive strengths called for on the plans, the engineer shall have the right to order a change in the proportions or the water content for the remaining portion of the structure. If the average strength of the jobcured cylinders falls below the required strength, the engineer shall have the right to require conditions of temperature and moisture necessary to secure the required strength and may require tests in accordance with the "Standard Methods of Securing, Preparing and Testing Specimens of Hardened Concrete for Compressive and Flexural Strengths"

(ASTM Designation: C 42) or order load tests to be made on the portions of the structure so affected.

4. Preparation of Equipment and Place of Deposit

(a) Before placing concrete, all equipment for mixing and transporting the concrete shall be cleaned, all debris and ice shall be removed from the places to be occupied by the concrete, forms shall be thoroughly wetted (except in freezing weather) or oiled, and the reinforcement shall be thoroughly cleaned of ice or other coatings.

(b) Water shall be removed from place of deposit before concrete is placed unless otherwise permitted by the engineer.

5. Mixing of Concrete

(a) The concrete shall be mixed until there is a uniform distribution of the materials and shall be discharged completely before the mixer is recharged.

(b) For job-mixed concrete, the mixer shall be rotated at a speed recommended by the manufacturer and mixing shall be continued for at least 1 minute after all materials are in the mixer.

(c) Ready-mixed concrete shall be mixed and delivered in accordance with the requirements set forth in the "Standard Specifications for Ready-Mixed Concrete" (ASTM Designation: C 94).

6. Conveying

(a) Concrete shall be conveyed from the mixer to the place of final deposit by methods which will prevent the separation or loss of the materials.

(b) Equipment for chuting, pumping and pneumatically conveying concrete shall be of such size and design as to insure a practically continuous flow of concrete at the delivery end without separation of the materials.

7. Depositing

(a) Concrete shall be deposited as nearly as practicable in its final position to avoid segregation due to rehandling or flowing. The concreting shall be carried on at such a rate that the concrete is at all times plastic and flows readily into the space between the bars. No concrete that has partially hardened or has been contaminated by foreign material shall be deposited on the work, nor shall retempered concrete be used.

(b) When concreting is once started, it shall be carried on as a continuous operation until the placing of the panel, section or lift is completed. The top surface of individual lifts shall be left with approximately a five degree slope, with the downstream side higher.

(c) All concrete shall be thoroughly compacted by suitable means during the operation of placing, and shall be thoroughly worked around reinforcement and embedded fixtures and into the corners of the forms.

8. Curing

Provision shall be made for maintaining concrete in a moist condition for at least five days after the placement of the concrete.

9. Cold Weather Requirements

(a) Adequate equipment shall be provided for heating the concrete materials and protecting the concrete during freezing or near-freezing weather. No frozen materials or materials containing ice shall be used.

(b) All concrete materials and all reinforcement, forms, fillers and ground with which the concrete is to come in contact shall be free from frost. Whenever the temperature of the surrounding air is below 40 deg. F. all concrete placed in the forms shall have a temperature of between 70 deg. F. and 80 deg. F., and adequate means shall be provided for maintaining a temperature of not less than 70 deg. F. for 3 days or 50 deg. F. for 5 days. The housing, covering or other protection used in connection with curing shall remain in place and intact at least 24 hours after the artificial heating is discontinued.

10. Forms

Forms shall conform to the shape, lines and dimensions of the members as called for on the plans, and shall be substantial and sufficiently tight to prevent leakage of mortar. They shall be properly braced or tied together so as to maintain position and shape. Forms shall be used for all surfaces where the slope is greater than 1 on 1-3/4.

Reinforcing

1. Cleaning and Bending Reinforcement

Metal reinforcement, at the time concrete is placed, shall be free from rust scale or other coatings that will destroy or reduce the bond. Bends for stirrups and ties shall be made around a pin having a diameter not less than two times the minimum thickness of the bar. Bends for other bars shall be made around a pin having a diameter not less than six times the minimum thickness of that bar, except that for bars larger than 1 in. the pin shall be not less than eight times the minimum thickness of the bar. All bars shall be bent cold.

2. Placing Reinforcement

Metal reinforcement shall be accurately placed in accordance with the plans and shall be adequately secured in position by concrete or metal chairs and spacers.

3. Concrete Protection for Reinforcement

The metal reinforcement shall be protected by the thickness of concrete indicated on the plans.

Construction Joints.

Vertical construction joints shall be not over 40' apart. Keyways shall be left between adjacent sections. The keyways shall be 4 feet wide by 1 feet deep. Copper membrane sealing strips shall be provided to prevent leakage through the vertical joints. The initial lift directly upon the rock foundation shall be of 2.5' thickness. Subsequent lifts shall be not greater than five feet. The rock foundation shall be cleaned as noted in the section under "Preparation of Rock Foundation for Concrete". After cleaning, all approximately horizontal rock surface shall be covered with a layer of mortar at least one-half inch thick, consisting of the regular concrete mixture without the coarse aggregates. The concrete mortar shall be thoroughly worked with brooms or otherwise into all irregularities of the surface. Concrete shall then be placed immediately upon the fresh mortar. All concrete surfaces which have set for twelve hours or more upon or against which concrete is to be placed and to which the new concrete is to adhere shall be cleaned of all laitence and loose or defective surface concrete, by means of jets of air and water applied at high velocity, by wet sand blasting, and /or chipping.

The surface of each lift or layer shall be washed immediately prior to the placing of the succeeding lift or layer of concrete and all water shall be removed from depressions before the concrete is placed. A one-half inch layer of mortar shall be applied to the cleaned surface before placing of the concrete begins.

Excavation

1. Dam.

Excavation for the dam and working space above the shale line shown on the plans shall be unclassified and included in the lump sum price bid for the dam.

2. Spillway.

The spillway below the dam shall be excavated to the finished contours shown on the plans, and shall be unclassified, and included in the lump sum price bid for the dam.

3. Trenches.

Excavation for pipe line trenches shall be of a depth as to provide 3 feet cover over the top of the pipe, and shall be unclassified and included in the price bid for relocated as well as on new pipe lines and drains.

4. Rock Excavation.

Rock excavation to depths below the shale line for the dam only, indicated on the plans as instructed by the Engineer, shall be paid for at the price bid per cubic yard.

5. Disposal of Excavated Material.

Excavated material, not suitable for backfill, shall be disposed of as directed by the Engineers.

Backfilling

1. Dam.

On completion of the dam, excavated areas above, below and at ends of the dam, shall be backfilled to the level of the adjacent ground level. Backfill shall be earthy material, free of large boulders placed in 12 inches layers and thoroughly compacted with hand or air tampers. No extra compensation will be made for backfill, same being included in the lump sum price bid for the dam.

2. Trenches shall be backfilled with earth material free of large boulders. For a depth of 12 inches, the backfill shall be thoroughly compacted. The remainder of the trench shall be filled to the level of the adjacent ground level and the trench left with a 6 inch mound.

Trenches in rock shall be backfilled as above specified.

Backfill shall be included in the lump sum price bid for the dam and in the price bid for pipe lines.

Drains

1. Reservoir drain.

Provide and install a 24 inch reservoir drain complete with gate valve at location shown on the plans. Pipe shall be Class C, B & S pipe with leaded joints. Gate valve shall be bell spigot ends Eddy taper seat, double gate valve or approved equal, for 150# working pressure. Anchor valve to pipe and valve bells with wrought iron collars and 1/2 inch stay rods. Cut off walls as hereafter specified.

2. <u>Foundation Drains</u>

Provide 3 inch foundation drains on 15 foot centers in bucket position of the dam as indicated on the drawings. Foundation drains shall be included in the lump sum price bid for the dam.

<u>Outlet Tower</u>

1. General.

Provide outlet tower as detailed on the plans. Concrete and reinforcement as hereinbefore specified. Tower and appurtenances on integral part of the dam and to be included in the price bid lump sum for the dam.

2. Sluice Gates.

Provide and install three (3) sluice gates with extension stems to operating platform of outlet tower. Sluice gates shall be Rodney-Hunt or approved equal, No. 320 for 24 inch square opening, with 1 1/2 inch rising stem. Provide a minimum of two (2) stem guides per gate, but in no instance shall spacing be greater than 10 feet. Provide "L" type anchor bolts and fasten gate securely to tower wall. Sluice gates are to be included in the lump sum price bid for the dam.

3. Floor Stands.

Provide Rodney-Hunt or approved equal, Floor Stands Type S-2600A for 1 1/2 inch rising stem. Provide 24 inches diameter hand wheel. Floor stands shall be rigidly attached with "L" type bolts embedded in tower concrete work. Floor stands to be included in the price bid lump sum for dam.

4. Railing.

Provide railing and stanchions along walkway and around tower as shown on the plans. Railing and stanchions pipe shall be "XH" galvanized wrought iron. Fittings shall be "XH" galvanized malleable iron. Railing and stanchions to be included in the price bid lump sum for the dam.

5. Ladder.

Provide within interior of the outlet tower an access ladder as detached and shown on the plans. Ladder shall be securely fastened with "L" bolts embedded in tower wall. Ladder to be included in the price bid lump sum for the dam.

6. Plate Cover.

Provide over opening in outlet tower an aluminum plate cover and frame, as detailed on the plans. Aluminum plate shall be "Alcoa" (615) or approved equal, standard pattern C-102. Frame shall be made of aluminum angles of sizes shown and provided with anchors. Frame to be securely attached to outlet walls. Provide steel bolts to secure cover plate to frame as detailed.

Water Lines

1. Relocated Main.

The present 8 inch main shall be lowered between Station 2 + 62 ± south and Station 1 + 86 ± north, approximately 400 feet ± in length. Pipe shall be lowered to invert elevations indicated on the plans. Care shall be taken in lowering pipe not to damage same, and all joints shall be recaulked. Where directed by the Engineer the present joint shall be burned out and the joint repoured and caulked. Relocated main will be paid for at the price bid per lineal foot.

2. New Main.

Provide 12 inch main from outlet tower and make connection to relocated present 8 inch main as shown on the plans. Connection to present relocated main shall be with a "Y" branch with gate valve and boxes on each main. Outlet ell, riser and run of pipe from outlet tower to outside edge of dam bucket shall be included in the lump sum price bid for the dam.

(a) Pipe and Fittings

Pipe shall be B & S, Class B cast iron pipe. Fittings shall be B & S, Class D. Pipe and fittings shall be A.W.W.A. Standards. Pipe shall be laid to the invert elevations shown on the drawings with caulked lead joints and true to grade and alignment.

(b) Gate Valves and Boxes.

At points indicated on the plans provide 8 inch gate valves and boxes. Gate Valves shall be A.W.W.A. Standard, "Eddy" as approved equal 150# W.P., bell end, tapered seat double gate valves. Valves shall have iron body, be bronze mounted, non-rising bronze stem with 2 inch square nut on stem.

Provide over each valve, a valve box complete with base, extension section, top section and cover.

(c) Cut Off Walls.

At locations indicated on the drawings, provide cut off walls around pipe lines to dimensions as detailed.

Chlorination Building

1. Building.

Provide chlorination building of dimensions shown on the plans. Footings and floor shall be of concrete of quality specified for concrete. Foundation and exterior walls shall be cement block masonry. Clear and grub building site.

Concrete masonry block for foundation and exterior walls shall be load-bearing, smooth surface, light weight aggregate type conforming to the provisions of A.S.T.M. Specifications C-90-44 and latest revisions thereof.

Masonry mortar shall comply with A.S.T.M. Specifications C-91-Type 2, and revisions thereof.

Plates, ties and roof rafters and sheeting shall be of heart yellow pine. Roofing shall be " 1 x Ternes", 28 gauge tin with standing Seam. The roof surface shall be covered with resin-sized building paper weighing at least 6 pounds per square. The tin roofing shall be secured to the roof sheeting with tin cleats 1 1/2" x 3", spaced not over 12 inches apart. All tin roofing shall be nailed with hot-dipped, zinc coated nails. Immediately after laying, all tin shall be given 2 coats of approved metallic roof paint, allowing one week for drying between coats.

Floor shall be provided with wire mesh reinforcement and finished with a float finish.

Door and frame shall be of steel Truscon - #3070. Complete with hardware.Window frames shall be of steel, Truscon - B-23141. Door and windows to be glazed.

Provide chimney flue with smoke pipe thimble and clean out door at location indicated on the plans. Move present stove to new building and erect complete with new smoke pipe, damper and elbows.

2. Chlorinators.

Provide a W & T or approved equal, A 334 direct feed type chlorinator, with 4# per day orifice meter, complete. The chlorinator shall be placed into operation prior to moving present chlorinator to the new building. Transfer and erect complete present chlorinator in new building.

3. Scales.

Provide one (1) "Fairbanks-Morse", or equal Code 1124 portable platform scale, 2000 pound capacity.

4. Distribution Lines and Box.

Provide gas tank manifold and 1/2 inch black W.I. supply line to chlorinators complete with pipe, fittings, valves, and connect to chlorinators as indicated on the drawings.

Provide distribution lines from chlorinators to distribution control complete with 1/2 inch black W.I. pipe fittings and valves.

From distribution control to pipe line main, provide 1/2 inch heavy duty distribution rubber hose. Between building and main, hose is to be run in a conduit consisting of B & S, V.C. or concrete pipe with cemented joints. Hose connection at main shall be through a corporation cock and a W & T diffuser as detailed on the drawings.

Provide over pipe line main at entrance of diffuser a concrete box with a cover and frame as detailed on the plans.

5. Painting.

All doors and sash shall on completion of glazing, paint with one (1) coat olive green metallic paint. Paint brand to be approved by the Engineers.

Roadway

1. Grading.

The contractor shall provide roadway at location, grade, and cross-section shown on the plans. Excavation shall be unclassified.

2. Drainage.

Provide drain pipe of corrugated metal of size, length and location shown on the plans.

PROPOSAL FORM

Item No.	DESCRIPTION	Quantity	Unit	Unit Price	Total
Schedule I.					
1.	Clearing & Grubbing, reservoir, dam spillway and roadway areas complete in accordance with plans & specifications		Lump Sum		$4000.00
Schedule II.					
1.	Constructing concrete gravity dam and spillway with appurtenances complete in accordance with plans & specifications		Lump Sum		160712.95
2.	Grout holes complete in accordance with plans and specifications	800	L.F.	2.75	2200.00
5 ~~3.~~	Relocating existing 8" water line in accordance with plans & specifications	400	L.F.	5.78	2312.00
6 ~~4.~~	Furnishing and installing 12 ~~8"~~ water line with connections to existing water line in accordance with plans and specifications	230 ~~200~~	L.F.	15.57	3575.70
7 ~~5.~~	Furnishing and installing Chlorinator building complete with chlorinator, scales, piping distribution hose and conduit, diffusor and diffusor box, in accordance with plans and specifications		Lump Sum		3036.73

Total of II. $ ________

#3 Grouting 1025.00

Total Base Bid...........$ ________

#4 Extra Conc. 1250.00

APPENDIX VI

CONCRETE TEST REPORTS

FROEHLING & ROBERTSON, INC.

INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS

SINCE F&R 1881

BRANCH LABORATORIES
NORFOLK, CHARLOTTE, RALEIGH
WASHINGTON, BALTIMORE

MAIN OFFICE & LABORATORIES
814 WEST CARY STREET
RICHMOND, VIRGINIA

No. E-4811-10

October 23, 1957

CONCRETE TEST REPORT

Project Woodstock Water Storage Dam, Woodstock, Virginia

Location Sampled Foundation 3+40 to 3+88

Designed Compressive Strength 3000 lbs. per sq. in. at 28 days. Date moulded 10/16/57

MATERIALS USED — BATCH OF CONCRETE

Cement 3.0 Sacks. Brand Lone Star Mfd. at Lone Star, Va.

Fine Aggregate 642 Pounds. Source Culpeper Size 100 to #4

Coarse Aggregate 1102 Pounds. Source TomsBrook Size #4 to 2"

Water 17.0 Gallons, including moisture in aggregates. Gals. water per sack 5-2/3

Admixture Darex Amount 2.3 ounces, Water-Cement Ratio Slump 1-1/2"

Made for Garrett, Moon & Pool, Inc., Blackstone, Virginia

Received 10/21/57 Condition:

Marked Air Content 4.4%

Curing: Field: to F° Period: | Damp Sand, to F° Period: | Moist Room, 73 F° Period: 2 days

COMPRESSIVE STRENGTH

TYPE OF BREAK

1 2 3 4 5 6 7

Lab. No.	Size Inches	Breaking Load Pounds	Pounds per Sq. In.	Weight Lbs. Per Cu. Ft.	Age at Test	Type of Break	Per Cent Aggregate Broken through Line of Fracture
5572	6 x 12	89,500	3165	147.1	7 days	2	5
5573	6 x 12	82,000	2900	147.1	7 days	2	4
5574	6 x 12				28 days		
5575	6 x 12				28 days		

Conclusions: Water added 13.1 gallons.

c Garrett, Moon & Pool, Inc., Blackstone, Va.
c Garrett, Moon & Pool, Inc., Box 37, Mt. Jackson, Va.

FROEHLING & ROBERTSON, INC.

INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS

SINCE F&R 1881

BRANCH LABORATORIES
NORFOLK, CHARLOTTE, RALEIGH
WASHINGTON, BALTIMORE

MAIN OFFICE & LABORATORIES
814 WEST CARY STREET
RICHMOND, VIRGINIA

No. E-4811-9

October 18, 1957

CONCRETE TEST REPORT

Project Woodstock Water Storage Dam, Woodstock, Virginia

Location Sampled Section 2/90 to 3/37.5 Approx. Elev. 1225 to 1230

Designed Compressive Strength 3000 lbs. per sq. in. at 28 days. Date moulded 9/20/57

MATERIALS USED — PER ~~CUBIC YARD~~ BATCH OF CONCRETE

Cement 3.0 Sacks. Brand Lone Star Mfd. at Lone Star, Va.

Fine Aggregate 642 Pounds. Source Culpeper Size 100 to #4

Coarse Aggregate 1102 Pounds. Source Toms Brook Size 2" to #4

Water 18 Gallons, including moisture in aggregates. Gals. water per sack 6

Admixture Darex Amount 2.5 ounces Water-Cement Ratio Slump 3-1/4"

Made for Garrett, Moon & Pool, Inc., Blackstone, Virginia

Received 9/26/57 Condition:

Marked Air 4.4%

Curing: Field: to F° Period:

Damp Sand, to F° Period:

Moist Room, 73 F° Period: 1 day 22 days

COMPRESSIVE STRENGTH

TYPE OF BREAK

No. Lab.	Size Inches	Breaking Load Pounds	Pounds per Sq. In.	Weight Lbs. Per Cu. Ft.	Age at Test	Type of Break	Per Cent Aggregate Broken through Line of Fracture
5008	6 x 12	63,000	2228	142.2	7 days	1	1
5009	6 x 12	60,000	2122	142.6	7 days	1	0
5010	6 x 12	89,500	3165	144.6	28 days	2	2
5011	6 x 12	84,000	2971	142.2	28 days	2	4

Conclusions:

1 cc Garrett, Moon & pool, Inc., Blackstone, Va.

4 cc Garrett, Moon & Pool, Inc., Box 37, Mt. Jackson, Va.

FROEHLING & ROBERTSON, INC.

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INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS
SINCE F&R 1881

BRANCH LABORATORIES
NORFOLK, CHARLOTTE, RALEIGH
WASHINGTON, BALTIMORE

MAIN OFFICE & LABORATORIES
814 WEST CARY STREET
RICHMOND, VIRGINIA

No. E-4811-10 October 8, 1957

CONCRETE TEST REPORT

Project Woodstock Water Storage Dam, Woodstock, Virginia

Location Sampled Section 2+50 to 2+90, Approx. Elev. 1245 to 1250

Designed Compressive Strength 3000 lbs. per sq. in. at 28 days. Date moulded 10/1/57

MATERIALS USED — ~~PER CUBIC YARD~~ OF CONCRETE

Cement 3.0 Sacks. Brand Lone Star Mfd. at Lone Star, Va.

Fine Aggregate 642 Pounds. Source Culpeper Size 100 to #4

Coarse Aggregate 1102 Pounds. Source C. S. Mundy, Toms Brook Size #4 to 2"

Water 18 Gallons, including moisture in aggregates. Gals. water per sack 6

Admixture Darex Amount 2.5 ounces Water-Cement Ratio Slump 2-1/2"

Made for Garrett, Moon & Pool, Inc., Blackstone, Virginia

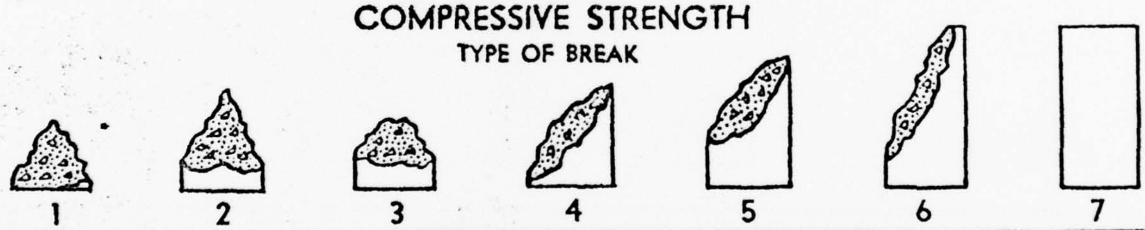
Received 10/5/57 Condition:

Marked

Curing: Field: to F° Period: | Damp Sand, to F° Period: | Moist Room, 73 F° Period: 3 days

COMPRESSIVE STRENGTH

TYPE OF BREAK



Lab. No.	Size Inches	Breaking Load Pounds	Pounds per Sq. In.	Weight Lbs. Per Cu. Ft.	Age at Test	Type of Break	Per Cent Aggregate Broken through Line of Fracture
5613	6 x 12	63,500	2246	145.7	7 days	2	0
5614	6 x 12	69,000	2440	145.7	7 days	2	0
5615	6 x 12				28 days		
5616	6 x 12				28 days		

Conclusions:

1 cc Garrett, Moon & Pool, Inc., Blackstone, Va.
4 cc Garrett, Moon & Pool, Inc., Box 37, Mt. Jackson, Va.

FROEHLING & ROBERTSON, INC.

Form CT-57

INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS

SINCE F&R 1881

BRANCH LABORATORIES
NORFOLK, CHARLOTTE, RALEIGH
WASHINGTON, BALTIMORE

MAIN OFFICE & LABORATORIES
814 WEST CARY STREET
RICHMOND, VIRGINIA

No. E-4811-9 September 19, 1957

CONCRETE TEST REPORT

Project Woodstock Water Storage Dam, Woodstock, Virginia

Location Sampled Dam and Between Elev. 127 and 133

Designed Compressive Strength 3000 lbs. per sq. in. at 28 days. Date moulded 9/11/57

MATERIALS USED — 3 BAG BATCH ~~PER CUBIC YARD~~ OF CONCRETE

Cement 3.00 Sacks. Brand Mfd. at

Fine Aggregate 642 Pounds. Source Size 100 to #4

Coarse Aggregate 1102 Pounds. Source Size #4 to 2"

Water 15.0 Gallons, including moisture in aggregates. Gals. water per sack

Admixture Darex Amount 2.5 ounces Water-Cement Ratio Slump 2-3/4"

Made for Garrett, Moon & Poole, Blackstone, Virginia

Received 9/16/57 Condition:

Marked

Curing: Field: to F° Period: | Damp Sand, to F° Period: | Moist Room, 73 F° Period: 2 days

COMPRESSIVE STRENGTH

TYPE OF BREAK

1 2 3 4 5 6 7

Lab. No.	Size Inches	Breaking Load Pounds	Pounds per Sq. In.	Weight Lbs. Per Cu. Ft.	Age at Test	Type of Break	Per Cent Aggregate Broken through Line of Fracture
4360	6 x 12	79,000	2794	142.6	7 days	1	2
4361	6 x 12	74,500	2635	143.1	7 days	1	2
4362	6 x 12				28 days		
4363	6 x 12				28 days		

Conclusions:

1 cc Garrett, Moon & Poole, Blackstone, Va.
4 cc Garrett, Moon & Poole, Box 37, Mt. Jackson, Va.

FROEHLING & ROBERTSON, INC.

Form CT-57

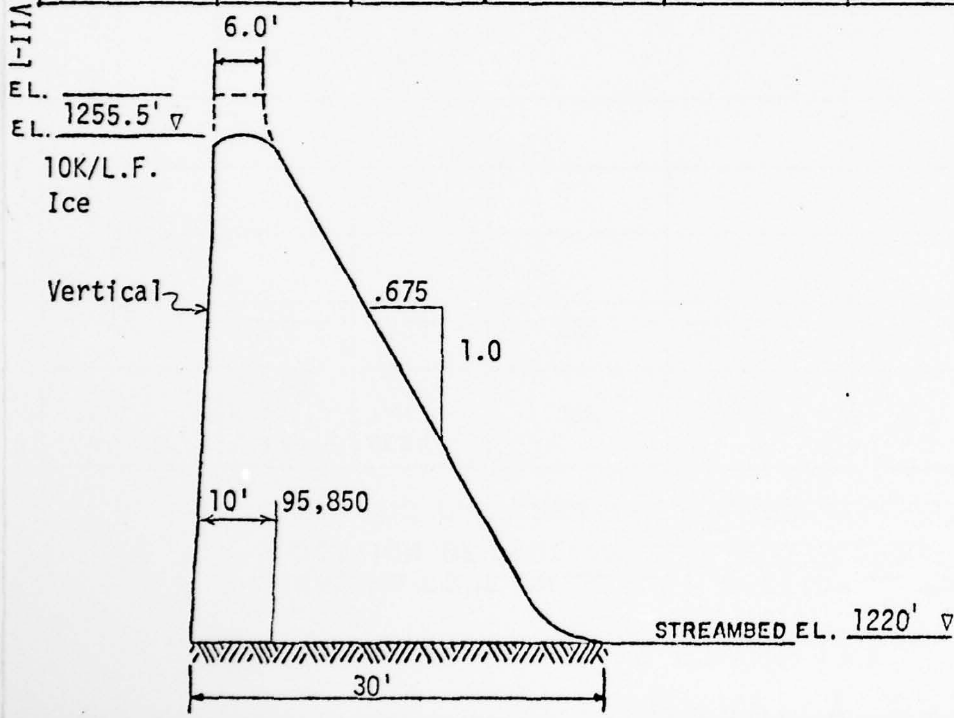
APPENDIX VII

STABILITY ANALYSES

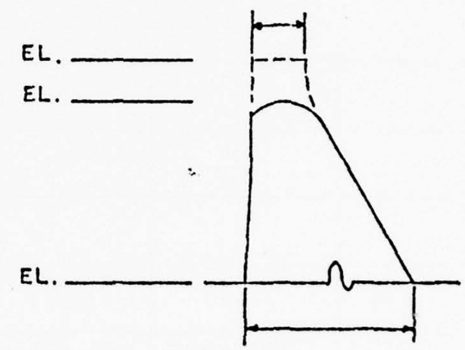
GRAVITY DAM DESIGN
STABILITY ANALYSIS

ANALYSIS DONE ON X FULL SECTION ___ PARTIAL SECTION
LOCATION OF SECTION ___
ANALYSIS PREPARED BY J. Thompson/J. Dziubek; Michael Baker, Jr., Inc.

LOADING CASE	ELEV. HEAD WATER	ELEV. TAIL WATER	ΣV	ΣH	$\frac{\Sigma H}{\Sigma V}$	LOCATION RESULTANT FROM TOE	% BASE IN COMPRESSION	FACTOR SAFETY SLIDING	FOUNDATION PRESSURE	
									TOE	HEEL
I	1255.5	1220	74,194	48,281	.65	9.39	94	10.8	5267	0
Ice Load Normal Pool										



FULL SECTION



PARTIAL SECTION

Woodstock Dam

GRAVITY DAM DESIGN

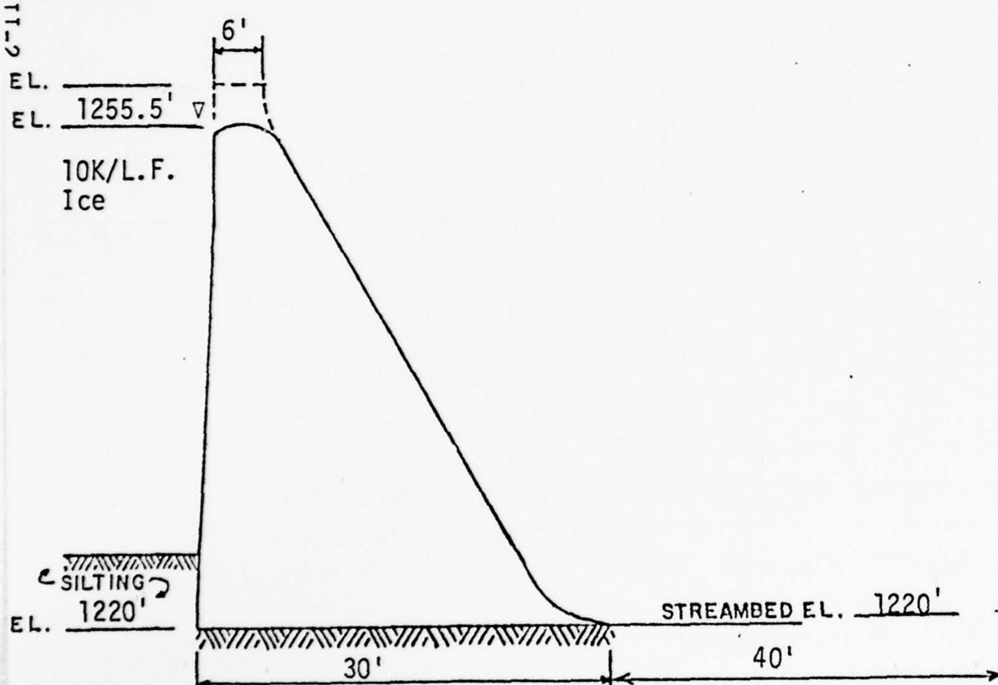
STABILITY ANALYSIS

ANALYSIS DONE ON _X_ FULL SECTION ___ PARTIAL SECTION

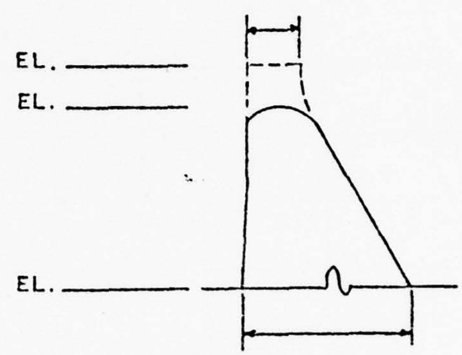
LOCATION OF SECTION: At point of seepage 70' downstream from heel

ANALYSIS PREPARED BY: J. Thompson/J. Dziubek; Michael Baker, Jr., Inc.

LOADING CASE	ELEV. HEAD WATER	ELEV. TAIL WATER	ΣV	ΣH	$\frac{\Sigma H}{\Sigma V}$	LOCATION RESULTANT FROM TOE	% BASE IN COMPRESSION	FACTOR SAFETY SLIDING	FOUNDATION PRESSURE	
									TOE	HEEL
II	1255.5	1220	61,286	48,281	0.79	9.22	92	10.5	4431	0
Ice Load Normal Pool Added Uplift Pressure										



FULL SECTION

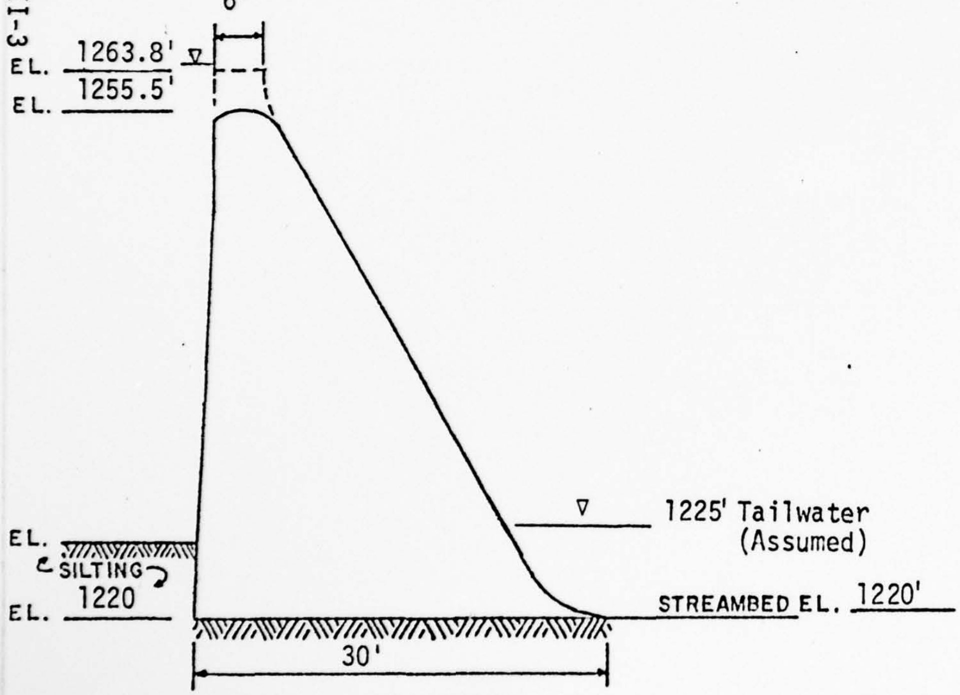


PARTIAL SECTION

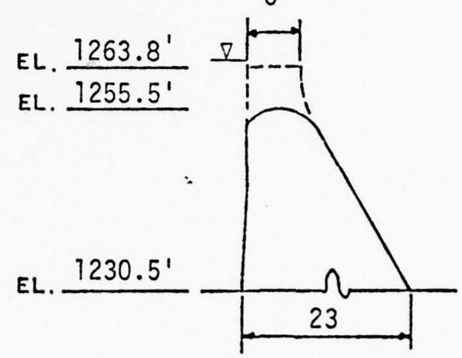
GRAVITY DAM DESIGN
STABILITY ANALYSIS

ANALYSIS DONE ON X **FULL SECTION** ___ **PARTIAL SECTION**
LOCATION OF SECTION Overflow
ANALYSIS PREPARED BY J. Thompson/J. Dziubek; Michael Baker, Jr., Inc.

LOADING CASE	ELEV. HEAD WATER	ELEV. TAIL WATER	ΣV	ΣH	$\frac{\Sigma H}{\Sigma V}$	LOCATION RESULTANT FROM TOE	% BASE IN COMPRESSION	FACTOR SAFETY SLIDING	FOUNDATION PRESSURE	
									TOE	HEEL
III	1263.8	1225	62,606	55,031	0.88	7.95	80	9.1	5250	0
Water at top of non-overflow section										
IIIA Partial Section	1263.5	-	41,290	32,030	0.78	7.1	92	47.8	-	-



FULL SECTION



PARTIAL SECTION

CASE IIIA

Woodstock Dam

APPENDIX VIII

CORRESPONDENCE FROM R. STUART ROYER, AND POULTON, MAHER AND BLAKE

R. STUART ROYER & ASSOCIATES
CONSULTING ENGINEERS
1514 WILLOW LAWN DRIVE
P. O. BOX 8687
RICHMOND, VIRGINIA 23226
AREA CODE 804 282-7657

PARTNERS:
I. N. KOONTZ, P.E.
J. A. LIMERICK, JR., P.E.
E. F. MASSIE, JR., P.E.

W. CARLE THURSTON
ADMINISTRATOR

ASSOCIATES:
S. P. TANSILL, P.E.
T. F. TURNER, JR., P.E
H. M. TYLER, P.E.
G. A. WEISHAAR, P.E.

HERBERT WILEY
CONSTRUCTION SUPERVISION

MBJ II
7/5/78
CIH A File
CYC w/e
JBD w/e
CYC

June 29, 1978

Michael Baker, Jr., Inc.
Engineers and Surveyors
4301 Dutch Ridge Road
P.O.Box 280
Beaver, Pa. 15009

Att: C.Y. Chen, Ph.D., P.E.

Re: Woodstock Dam
Shenandoah County, Virginia

Gentlemen:

This is in response to your request by telephone and your letter of June 5, 1978 regarding the background data on the above referenced facilities.

The construction plans and specifications for the above dam were prepared by our firm in 1955 for the Town of Woodstock and we engaged Poulton, Maher and Blake, Structural Engineers of Blacksburg, Virginia to provide the structural design criteria for the facilities. We are enclosing a copy of a letter and drawing dated August 15, 1955 from P.M. & B. setting forth their recommendations.

The dam was constructed by Garrett, Moon & Pool, Inc., of Blackstone, Virginia in 1957-58 with our firm providing general supervision.

When the overburden was removed and the shale along the dam site exposed, it was found necessary to carry the excavation below the elevations shown on the construction plans in order to obtain a suitable foundation. At that time it was found impractical to develop the cut off wall under the dam as originally shown on the plans. We are enclosing herewith a profile of the dam looking upstream with the actual foundation line along the dam axis shown in red and the foundation line along the toe of the dam shown in blue. The shale foundation was grouted

RSR

along the dam axis at approximately 10 foot centers to seal the fissure in the shale and create a barrier against leakage under the dam.

When the dam was completed and filled with water in 1958, a leak developed 10 to 20 feet downstream on the east side or right hand side of the creek when looking upstream. When the water level was lowered to approximately mid depth the leak stopped. An effort to determine where the source of the leak was located along the side of the reservoir met with no success.

Observations of the leak revealed that it was fairly constant without a boil led to the conclusion that it was seepage through fissures in the shale that had not been sealed by grouting. Over the past twenty years, we have made periodic inspections and found the leak to remain constant. The leaking water is clear and there is no sediment deposit at its outlet. Based on these observations, we are confident that our above conclusion is reasonable and correct. I personally inspected the leak approximately 18 months ago and again in May and saw no indications of erosion or piping.

I have not been able to find the hydrologic calculation in our files and believe they were lost or misplaced when we moved our office approximately seven years ago. The drainage area tributary to the reservoir contains approximately 7.6 square miles. Based on the spillway capacty of 7,270 cfs set forth in Mr. Maher's letter, the spillway could handle a runoff at the rate of approximately 1.48 in./hr. All of the drainage area is wooded and should remain so since it is owned by the National Forest Service.

I believe the above summarizes the information requested in your letter to the best that we can; however, should you have any further questions please advise.

Sincerely,

R. STUART ROYER & ASSOCIATES

By E. F. Massie, Jr.
E. F. Massie, Jr.

jp
Enclosure
cc: Mr. James H. Blount, Jr., Town Manager
Town of Woodstock, Virginia

POULTON, MAHER, AND BLAKE
STRUCTURAL ENGINEERS
BLACKSBURG, VIRGINIA

JOHN F. POULTON
F. J. MAHER
OSCAR J. BLAKE

August 15, 1955

R. Stuart Royer & Associates
Consulting Engineers
15 West Cary Street
Richmond, 20, Virginia

Gentlemen:

Attached hereto are copies of the results of the design of the proposed concrete gravity dam for the Town of Woodstock, Virginia.

A number of factors influencing the design and specifications are outlined below.

1. DESIGN FLOOD FLOW.- The report originally furnished us estimated the flood flow at 1,915 cfs, based on the flow from a relatively much larger drainage area. Since the drainage area is so small, a much larger rate of flow per square mile must be assumed. Using the Myers Formula with the applicable factor for the locality, a flow of 7,160 cfs was obtained. Ignoring the factors of concentration time and additional reservoir capacity, the above figure was taken as a design flood.

2. SPILLWAY.- A 'primary' spillway 20 feet wide with crest at elevation 1255.0 has been provided for ordinary flow. The primary spillway will handle about 24 cfs before the rest of the spillway is needed. A 'secondary' spillway totalling 140 feet in length with crest at 1255.5 should handle additional flow due to the design flood. The combined capacity with flood level at elevation 1260.5 is about 7270 cfs. The spillway crests follow the standard crests for flows about 0.4 feet higher than the flood level. This overdesign was an expedient to make the curve fit the proportions of the section. It also represents an additional factor of safety since an underdesigned spillway may be troublesome from several points of view.

3. PROPORTIONS OF SECTIONS.- In proportioning the section, five cases were taken for analysis as follows;

a) Weight of Dam- Reservoir empty
b) Weight + 0.1g Earthquake (acting upstream)
c) Weight + Flood Pressure
d) Weight + Flood Pressure + 67% Uplift
e) Weight + Normal Pressure + Earthquake + Uplift
Note: Normal pressure refers to hydrostatic pressure with the free surface at elevation 1255.5 plus additional water pressure due to earthquake.

With the exception of case (b), allresultants lie within the middle third boundaries. The condition of earthquake ocurring when the dam is empty, produces an action line upstream with reppect to the middle third

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section. Direct tensile stresses produced by this action are of the order of 6.0 psi on the downstream face. Considering the coincidences which must occur to produce such action and the low values of stress in this low dam, this difficulty was finally ignored. Several changes were tried without significant improvement in the action line and with appreciable increase in volume. Such increase did not seem justified under the circumstances.

The downstream slopes of both the overflow and non-overflow sections were made the same. Some small reduction might have been made in the non-overflow portion, but the possible saving seemed insignificant. In larger combination dams, the two sections may be separated by some type of wing wall to prevent spreading of the jet. In this case it would appear simpler to extend the bucket about ten feet into the non-overflow section to take care of the spread.

FOUNDATION.- In the profile furnished us, some steps were sketched, probably in making some preliminary estimates. There appears to be no real reason for making definite steps in the rock foundation for a gravity dam. Steps are necessary for an arch dam.

In the report of the geologist, no mention is made of the nature of the shale. A compacted shale will disaggregate when immersed after being dried. A simple test consists of immersing a piece of the dry material for several days. Some reassurance from the geologist of Froehling and Robertson should be obtained on this point.

SPECIFICATIONS.- The specifications represent abstracts or paraphrasing of the following sourses;

a) "Design and Control of Concrete Mixtures" Ninth Edition, Portland Cement Association
b) " Low Dams" National Resources Committee
c) Specifications- Philpott Dam, Corps of Engineers
d) "Engineering for Dams" Creager, Justin and Hinds John Wiley and Sons
e) " Design of Dams" Hanna and Kennedy, McGraw-Hill Book Co.

Relative to the set of specifications used by R. Stuart Royer & Associates, the only criticism would appear to be that they are overly detailed as to proportions while not specifying the water-cement ratios. " By fixing the water-cement ratio and the workability, but leaving considerable leeway to the contractor in his selection of materials, proportions and consistency, the interests of the contractor and owner become very much alike" (Design and Control of Concrete Mixtures", PCA, Ninth edition, Chapter 14, Page 50.)

OUTLET TOWER.- The location of the slide gates is somewhat arbitrary and may be changed if desired. Handwheel type lifts have been selected rather than the crank types because the larger clearances required with the latter would necessitate a larger platform or larger tower. It is

POULTON, MAHER, AND BLAKE
STRUCTURAL ENGINEERS
BLACKSBURG, VIRGINIA

JOHN F. POULTON
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OSCAR J. BLAKE

recommended that protective railings be installed around the tower and edge of the non-overflow section, at least. Probably, ladder rungs should be cast in the vertical face of the non-overflow section leading down to the spillway section.

QUANTITY.- The volume of concrete in the dam and tower is estimated at 6650 cubic yards. This will vary depending on the location of the rock foundation.

We hope that this letter and attached information provide you with the information originally requested of us. If additional information is needed or any points require clarification, please do not hesitate to call on us. We would appreciate having notification of any changes made and would appreciate also having copies of the pertinent final drawings.

Very truly yours
Poulton, Maher and Blake

F. J. Maher

F. J. Maher

AD-A063 545 BAKER (MICHAEL) JR INC BEAVER PA F/G 13/2
NATIONAL DAM SAFETY PROGRAM. POTOMAC RIVER BASIN. WOODSTOCK (IN--ETC(U)
AUG 78 M BAKER DACW65-78-C-0016

UNCLASSIFIED NL

2 OF 2
AD
A063 545

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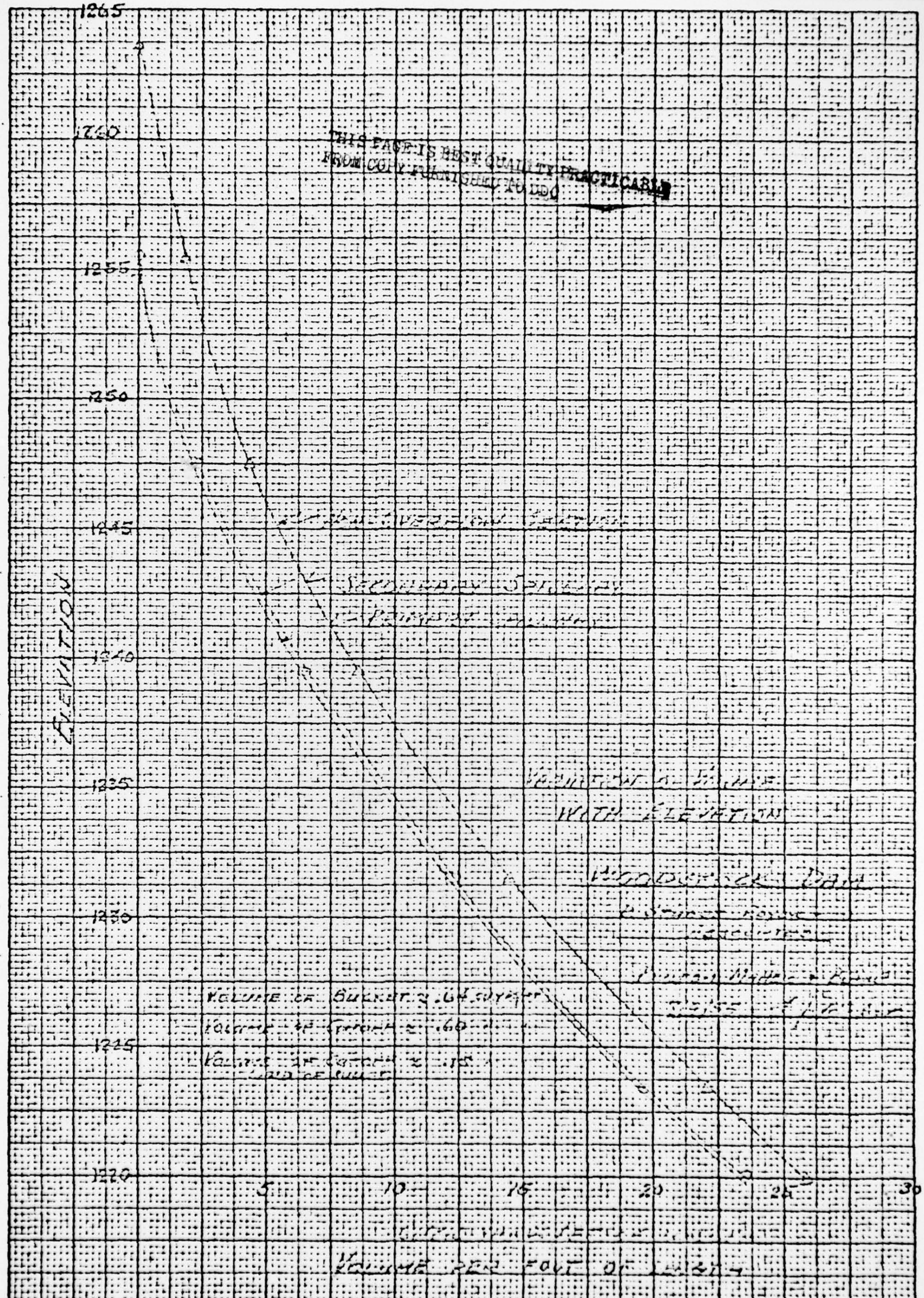
ELEVATION
1265
1260
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25
30
WITH ELEVATION
VOLUME OF BUCKET ≈ .64 CU YD
VOLUME PER FOOT OF LENGTH

APPENDIX IX

U.S. FOREST SERVICE DAM INSPECTION FORM

USDA-FOREST SERVICE

DAM MAINTENANCE INSPECTION REPORT

Ref: FSM 7572.23

1. REGION (3-4)	2. FOREST (5-6)	3. RANGER DIST. (7-8)	4. FOREST INV. NO. (9-12)
08	08	04	0006

5. NAME OF DAM: Woodstock

BLOCK I - MAINTENANCE INSPECTION CHECKLIST

ITEM (Describe deficient items on attached sheets)	NEEDED REPAIRS (By priority) 1	2	None
1. EMBANKMENTS			
a. Slumps, slides			✓
b. Settlement			✓
c. Cracks			✓
d. Seepage			✓
e. Erosion			✓
f. Slope facing			✓
g. Debris			✓
h. Traffic damage			✓
i. Brush, trees			✓
j. Burrows			✓
k. Other			
2. CONCRETE STRUCTURES			
a. Settlement			✓
b. Overturning			✓
c. Heaving			✓
d. Cracks, spalls		✓	
e. Joints — Joints leak.		✓	
f. Undermining		✓	⊘
g. Drains			✓
h. Seepage		✓	
i. Other			
3. GATES, CONTROLS			
a. Corrosion			✓
b. Mechanical			✓
c. Structural			✓
d. Clogging			✓
e. Access			✓
f. Other			

ITEM (Describe deficient items on attached sheet)	NEEDED REPAIRS (By priority) 1	2	None
4. CLOSED CONDUITS			
a. Settlement			✓
b. Displacement			✓
c. Cracks, spalls			✓
d. Seepage			✓
e. Clogging			✓
f. Erosion		⊘	✓
g. Corrosion		✓	
h. Joints			✓
i. Other			
5. SPILLWAYS			
a. Obstructions			✓
b. Erosion			✓
c. Structural			✓
d. Vegetation			✓
e. Other			
6. DOWNSTREAM CONDITION			
a. Backwater			✓
b. Erosion			✓
c. Bars, pools			✓
d. Boils, piping			✓
e. Other			
7. RESERVOIR			
a. Shore erosion			✓
b. Debris			✓
c. Sediment			✓
d. Other			
8. OTHER *(Identify)*			
a.			
b.			
c.			
d.			

CARD NO. 12

(OVER)

7500-2 (2/69)

BLOCK II - MAINTENANCE COST ESTIMATE

ITEM OF WORK	UNIT	UNIT COST	QUANTITY PRIORITY 1	QUANTITY PRIORITY 2	COST PRIORITY 1	COST PRIORITY 2
2(d), (e), (f) + (h) – These leaks cracks and joints will have to be repaired. 4(g) – Corrosion of pipe. Pipe needs to be checked for structural defects. This dam should be checked as agreed to by the city of Woodstock. They had planned to have their A&E Firm to inspect the Dam						
TOTALS (Enter in Block III, below) ▶						

BLOCK III - SUMMARY MAINTENANCE INSPECTION REPORT

1. DATE OF INSP. (13 18)	2. HIGHEST PRIORITY CHECKED IN BLOCK 1. (19)	3. EST. MAINT. COST ($1,000) a. PRIORITY 1 (20 23)	b. PRIORITY 2 (24 27)
9/2/77 MO. DAY YR.	–	– – – . –	– – – . –

4. EST. ENGINEER TIME NEEDED (MAN-HR.) a. PRIORITY 1 (28 30)	b. PRIORITY 2 (31 33)	5. EST. AID & TECH. TIME NEEDED (MAN-HR.) a. PRIORITY 1 (34 36)	b. PRIORITY 2 (37 39)
– – –	– – –	– – –	– – –

6. NOTICE TO OWNER (40)	7. DATE OF NOTICE (41 46)	8. LIMITATION (47)
YES / – NO	– –/– –/– – MO. DAY YR.	YES / – NO

9. TYPE OF LIMITATION (48)	10. REVISED ESTIMATE OF INSPECTION TIME (MAN-HRS.) a. ENGINEER (49-50)	b. FOREST OFFICER (51-52)	c. AID & TECH. (53-54)
–	– –	– –	– –

CARD NO. 12

REPORTED BY (Name & signature)	TITLE	DATE
Richard Loraux	Civil Eng.	9-26-77

GPO 870-911