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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

AD A077472



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DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS
803 FRONT STREET
NORFOLK, VIRGINIA 23510

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SEPTEMBER 1979

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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.

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (flood discharges that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the design flood should not be interpreted as necessarily posing a highly inadequate condition. The design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

CONTENTS

	Page
Preface	i
Brief Assessment of Dam	1
Overall View of Dam	5
Section 1: Project Information	7
Section 2: Engineering Data	11
Section 3: Visual Inspection	15
Section 4: Operational Procedures	19
Section 5: Hydraulic/Hydrologic Data	21
Section 6: Dam Stability	23
Section 7: Assessment/Remedial Measures	27

Appendices

I. Plates
II. Photographs
III. Check List - Visual Inspection
IV. Check List - Engineering Data
V. Field Inspection Reports
VI. Embankment Construction Specifications
VII. Letter from Owner
VIII. General References

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Robertson Dam
State: Virginia
County: Rockbridge
USGS 7.5 Minute Quadrangle: Collierstown, Virginia
Stream: Colliers Creek
Date of Inspection: 5 June 1979

BRIEF ASSESSMENT OF DAM

Robertson Dam is a zoned, earthfill embankment approximately 52 feet high and 400 feet long. The dam, located approximately 1.5 miles upstream of Collierstown, Virginia, is used for recreation. Robertson Dam is an "intermediate" size - "high" hazard structure as defined by the Recommended Guidelines for Safety Inspection of Dams. Visual inspection and office analyses indicate deficiencies requiring additional attention.

Using the Corps of Engineers' screening criteria for initial review of spillway adequacy, the Probable Maximum Flood (PMF) was selected as the spillway design flood (SDF). The SDF was routed through the reservoir and found to overtop the dam by a maximum depth of 2.8 feet with an average critical velocity of 4.4 f.p.s. Total duration of dam overtopping would be approximately 2.8 hours. The combination of the instability of the downstream embankment at the right abutment and the seriously inadequate spillways represent a higher potential for dam failure during overtopping of the embankment crest. The spillways are capable of passing only 35 percent of the PMF and are therefore considered seriously inadequate. The area of sloughing and clear seepage at the junction of the right abutment and downstream embankment was the most severe condition noted during the field inspection. The dam is classified as unsafe, non-emergency.

It is therefore recommended that within two months of the date of notification of the Governor of the Commonwealth of Virginia, the owner engage the services of a professional engineering consultant to analyze the embankment stability and the spillway adequacy. Within six months of the notification of the Governor, the consultant's analyses and recommendations should be completed and the owner should have an agreement with the Commonwealth of Virginia for a reasonable time period in which all remedial measures will be complete. In the interim, an emergency operation and warning plan should be developed and the seepage at the junction of the embankment and right abutment should be monitored during periods of heavy runoff. The owner has indicated (see Appendix VII)

that they are currently in the process of securing funding for undertaking corrective measures.

The following remedial measures should be accomplished as part of the general maintenance of the dam: repair rodent holes on the embankment, repair the concrete apron at the outlet pipe, repair slump area at the junction of the left downstream embankment slope and the emergency spillway discharge channel, remove trees from the embankment and emergency spillway, and install a staff gage in the reservoir.

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

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Jack G. Starr
Chief, Engineering

APPROVED: Original signed by: Douglas L. Haller

Douglas L. Haller
Colonel, Corps of Engineers
District Engineer

Date: SEP 21 1979



OVERALL VIEW OF DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NAME OF DAM: ROBERTSON DAM ID# VA 16303

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: Robertson Dam is a zoned, earthfill embankment approximately 52 feet high[1] and 400 feet long. The downstream side slope of the dam is 2.5:1 (horizontal to vertical). The upstream slope is 3:1 below a 4 foot wide bench at normal pool elevation and 2.5:1 above the bench. The crest of the dam is 8 feet wide and varies only slightly in elevation along the length of the dam. Rock riprap slope protection is provided from this bench to within 3.5 feet of the crest of the dam at elevation 152 feet. Seepage control is provided by a clay core wall which extends 3 feet beneath the embankment.

The principal spillway (crest elevation 145.0 feet[2]) is a drop-inlet type structure consisting of a 6 foot square reinforced concrete riser approximately 42 feet high. A 24 inch diameter cast-iron pipe discharges

[1]Measured from the streambed at the downstream toe to the embankment crest.
[2]Assumed datum from design plans.

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into a plunge pool at the downstream toe of the embankment. This outlet pipe, approximately 280 feet long, is supported by a concrete cradle and is provided with 4 cut-off collars along its length. An 18 inch square sluice gate located on the upstream side of the riser can be used for draining the reservoir. This gate is manually operated from the top of the riser tower.

The emergency spillway is an open channel type spillway located at the left abutment of the embankment. The 60 foot wide control section has a crest elevation of 147.0 feet and a side slope of 12:5 (horizontal to vertical) on the right[3] side of the spillway. The right side slope is paved with concrete to prevent erosion of the embankment during excessive discharges through the spillway. The left side of the spillway, at the control section, is cut in rock and is nearly vertical.

1.2.2 Location: Robertson Dam is located on Colliers Creek approximately 1.5 miles upstream (northwest) from Collierstown, Rockbridge County, Virginia.

1.2.3 Size Classification: The maximum height of the dam is 52 feet; the reservoir storage capacity to the crest of the dam is 678 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: The community of Collierstown is located approximately 1.4 miles downstream from the dam. Several homes are located in low-lying areas and, therefore, loss of life as well as extensive economic losses could occur in the event of a dam failure by overtopping. The dam is therefore classified in the "high" hazard category as defined by the 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 Commission of Game and Inland Fisheries, Richmond, Virginia.

[3]Facing downstream.

1.2.6 Purpose: The dam was constructed as a recreational facililty.

1.2.7 Design and Construction History: The dam and appurtenances were designed by Warren C. Perrow, Consulting Engineer, Richmond, Virginia. The dam was constructed by Charles W. Barger and Son Construction Company, Inc.

1.2.8 Normal Operational Procedures: The reservoir is typically maintained at the normal pool elevation of 145.0 feet by the crest of the riser. No formal operating procedures are followed for the dam.

1.3 Pertinent Data

1.3.1 Drainage Area: The drainage area tributary to the reservoir is 1.04 square miles.

1.3.2 Discharge at Dam Site: The maximum flood at the dam site occurred in June 1972 during Tropical Storm Agnes. During the storm, the reservoir rose to a level of approximately 0.5 inch above the emergency spillway crest. This corresponds to a maximum discharge from the reservoir of approximately 82 c.f.s.

Principal Spillway:
Pool level at top of dam . . 85 c.f.s.

Emergency Spillway:
Pool level at top of dam . . 2150 c.f.s.

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

TABLE 1.1 DAM AND RESERVOIR DATA

		Reservoir Capacity			
Item	Elevation	Area acres	Acre-feet	Watershed inches	Length miles
Top of dam	152.0	33.3	678	12.2	0.66
Emergency spillway crest	147.0	28.6	524	9.4	0.58
Principal spillway crest (normal pool)	145.0	26.7	468	8.4	0.53
Streambed at downstream toe of dam	100.0	-	-	-	-

SECTION 2 - ENGINEERING DATA

2.1 Design: The design plan, specifications, boring logs, field inspection reports, and miscellaneous correspondence were available for use in preparing this report. (No other information, such as soils laboratory analyses, was available.) The plan was prepared by Warren C. Perrow, Consulting Engineer, Richmond, Virginia.

The boring logs, as shown on the General Plan sheet (Plate 2), contain little information regarding embankment foundation conditions or borrow sources. The logs contain only the remarks "no rock" or "river jacks". The 16 borings ranged in depth from 1 to 5 feet; 15 were in the reservoir area and one was drilled beneath the upstream embankment toe. The 5 foot deep boring in the embankment area simply indicates "no rock".

The General Plan sheet also shows rock outcrops on both downstream abutments. The rock type is not specified. On the right side, in the vicinity of the present embankment slide, the rock outcrop is shown to extend from above the embankment down to near the original stream location. On the left abutment the outcrop was less extensive. The plan shows a spring on the left upstream abutment, approximately 80 feet from the upstream slope, at approximate elevation 125 feet. The typical section for the embankment shows a uniform 2.5:1 downstream embankment slope. The upstream slope ratio was designated as 3:1 from the toe up to elevation 145.0 feet where a 4 foot wide berm was to be constructed. Above the berm to the crest, the designed slope ratio was 2.5:1. A 23 foot wide, 3 foot deep core wall was to have been cut along the dam centerline. No toe drains were specified. Apparently the dam was constructed directly on the foundation soil, although unstable foundation material was to be removed as found during construction.

According to the construction specifications (Appendix VI) and the typical section, the embankment was to have been constructed in three zones. Zone 1, consisting of the central core and core wall, was to have been constructed of "the best clay available from the site"; no rock over 3 inches in diameter was to be used. Zone 2, the upstream section of the shell, was to have been built from "the second best clay available from the site", excluding rock larger than 6 inches in diameter. Zone 3, the downstream section of the shell, was to have been constructed of compacted "material unsuitable for either Zone 1 or 2".

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All suitable materials to be used in constructing the embankment were to have been placed in maximum lifts of 6 inches, after an initial lift of 3 inches. One hundred percent of maximum density, per AASHO Method T-99, was specified. A total of three compaction tests by an approved testing agent were required by the specifications, at the direction of the Engineer. However, subsequent correspondence indicates that the firm of Hayes, Seay, Mattern, and Mattern, Roanoke, Virginia, was apparently engaged to provide full time compaction control for the dam.

2.2 Construction: The dam, constructed by Charles W. Barger and Sons Construction Company, Inc., was completed in 1970. Construction records, as-built plans, and inspection logs were not available for review.

2.3 Operation: No formal operation records are maintained for the dam. However, three inspections were made in 1972 at the owner's request by representatives of the consulting firm of Froehling and Robertson, Inc., Richmond, Virginia. Complete reports of these inspections are presented in Appendix V. These inspections were made to evaluate the cause(s) and the adequacy of remedial measures for slides which were found in the area of the southwest (right) downstream abutment.

The initial inspection by Froehling and Robertson, Inc. was made on March 17 and 18. At that time, it was concluded that the soil slumping was caused by lack of proper internal drainage, low degree of compaction of embankment materials, and the dip of rock in the abutments. The dip of rock was felt to be the major contributing factor to the failures because solution cavities in the limestone and bedding planes could direct the flow of ground water into the slide area. Sand bagging was suggested as a temporary corrective measure, along with close observation of seepage rates and turbidity changes.

The second inspection was made on June 26 to investigate additional slumping in the same location which allegedly resulted from Tropical Store Agnes. It was recommended that the slumped material be removed and replaced with properly compacted material; sand bagging of each abutment from the toe upward was also suggested.

The final inspection was made by Froehling and Robertson, Inc. on September 25 to inspect repairs being made to the slide area. The slide material had been removed to limestone bedrock, exposing clear seepage (approximately 0.5 g.p.m.) from one of the bedding planes. It was concluded that this seepage was the probable cause of

the slope failure. As the result of this inspection, it was recommended that a "weep" be installed to drain the area prior to backfilling with compacted soil. Sand bagging the area was again recommended, along with monitoring the drainage for volume or turbidity changes.

2.4 Evaluation: No stability analyses or hydrologic and hydraulic data was available for review. No construction records or as-built plans were available to adequately assess the condition of the dam. All evaluations and assessments in this report were based upon field observations and office analyses.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

3.1.1 General: The field inspection of Robertson Dam was conducted on 5 June 1979 during warm and sunny weather. The reservoir level was at normal pool at the time of the inspection and ground conditions were dry. The dam was found to be fairly well maintained except for a few unstable embankment areas which are related to seepage and erosion problems. The appurtenant structures were generally found to be in good condition.

Plate 1 is a Field Sketch of the dam as built which depicts the conditions found during the inspection. The complete visual inspection check list is included in Appendix III. Following are brief summaries of the deficiencies noted during the inspection.

3.1.2 Dam: A zone of sloughing approximately 20 feet wide extends from the crest of the dam to the toe of the downstream slope (sloped at 2.5:1) near its junction with the right abutment (see Plate 1 and Photo 7).

A 2 inch diameter plastic drain pipe was discharging approximately 0.8 g.p.m. at the time of the visual inspection. This pipe discharges at the toe of the embankment slope near the junction of the downstream embankment with the right abutment (see Photo 6). (This pipe is probably the "weep" installed in 1972 to drain the slide area.) An additional iron-stained seep, totaling less than 2 g.p.m., is present in this same area, downslope from the slide. Combined, these seeps result in a small swamp to the right of the principal spillway. Surface drainage along the junction of the downstream embankment slope with the right abutment is not channeled properly and this water spreads across the slide area aggravating the situation. The slide area is hummocky and a 1 foot deep gully has been eroded near the base of the affected area.

Approximately halfway up the left junction of the embankment with the emergency spillway

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discharge channel, minor slumping has occurred (see Plate 1). Clear seeps (too small to measure) are occurring in this area which are probably related to bedrock springs. This assumption is supported by the presence of a spring which was noted during the planning stage. The spring is at approximately the same elevation as the bedrock outcrop on the left abutment and just upstream of the dam centerline (see bedrock and spring indicated in the left abutment area on Plate 2). Surface runoff and a few animal burrows are aggravating this condition.

The limestone exposed in the bedrock cut of the emergency spillway is folded and highly fractured (see Photo 4). Two small cavernous areas or solution channels were also detected in this exposure.

The riprap on the upstream embankment (sloped at 2.5:1) is generally in good condition with the exception of approximately the right 100 feet. The riprap has deteriorated and is patchy on this segment. The upstream embankment slope was not riprapped to the crest of the dam (see Overall View of Dam) contrary to the design specifications (see Plate 2). Approximately the top 3.5 feet of the embankment slope is only grass covered, but it is in excellent condition.

A few small trees are growing on the embankment. The most significant are rooted at the edge of the concrete slab protecting the embankment in the emergency spillway (see Overall View of Dam). These trees could loosen the soil of the upstream slope and allow water to undercut the slab during high water periods.

3.1.3 Appurtenant Structures: Minor erosion and a few unvegetated areas were observed in the discharge channel of the emergency spillway. The left downstream corner of the concrete apron, onto which the dam outlet pipe discharges, has begun to deteriorate. Insufficient riprap surrounds the upstream sides of the stilling basin and the outlet structure to provide protection for the toe of the dam (see Photo 3 and Plate 1).

3.1.4 Reservoir Area: No apparent unstable areas were noted in the reservoir area. The slopes are moderately steep and heavily wooded (see Photo 2). One sinkhole was observed on the eastern reservoir slope immediately upslope and adjacent to the footpath which circles most of the reservoir.

3.1.5 Downstream Channel: The downstream channel in the vicinity of the outlet structure and the emergency spillway discharge channel is unobstructed. Approximately 500 feet downstream of the dam the channel is narrow and overgrown by trees (see Photo 5).

3.2 Evaluation: The most serious condition discovered during the field inspection was the zone of sloughing along the junction of the downstream slope with the right abutment. The sloughing of the embankment in this area and the corresponding seepage indicate a potential for piping failure and/or sliding failure of the embankment. Furthermore, since the seepage is not unusually high and no piping was evident, the sloughing may indicate an even more serious potential for embankment instability due to sliding. Although corrective measures were previously instituted, further remedial measures will be necessary to collect seepage and restrict sloughing.

The slump area at the left junction of the embankment with the emergency spillway discharge channel, although not as serious as the slump area at the right abutment, should be repaired at the same time.

Other items discovered during the inspection which should be corrected as part of the general maintenance are: repair rodent holes, add additional riprap to the left end of the upstream embankment, remove trees from the embankment and emergency spillway, repair corner of the concrete apron near the outlet pipe, repair erosion on the embankment and emergency spillways, and install a staff gage in the reservoir.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures: Operation of the dam is automatically maintained by the principal spillway and emergency spillway. The design normal pool is maintained at elevation 145.00 feet by the principal spillway riser tower (see Plate 2 and Photo 1). When the capacity of the riser tower is exceeded, water rises in the reservoir to elevation 147.00 feet. Above this elevation, water discharges through the emergency spillway (see Photo 4) and is prevented from washing onto the toe of the dam by a berm along the right side of the discharge channel (see Plate 1).

Emergency drawdown of the reservoir is possible by means of a hand operated 18 inch square sluice gate. The hand crank is situated on the upstream side of the riser tower (see Photo 1). Complete draining of the reservoir is possible using this gate.

4.2 Maintenance of Dam: Maintenance of the dam is the responsibility of the owner. Inspections and repairs have been made since the dam was built. The owner cuts the grass, removes debris from the lake, and provides other general maintenance on an as-needed basis.

4.3 Maintenance of Operating Facilities: Maintenance of the operating equipment is the responsibility of the owner. The only operating equipment for this dam is the sluice gate on the tower.

4.4 Warning System: At the present time, there is no warning system or evacuation plan in operation.

4.5 Evaluation: Repairs have been made to the dam as necessary and maintenance has been fairly good to date from general appearance. However, an extensive check list should be compiled and used in regular inspections of the dam, appurtenant structures, and operating equipment. A staff gage should be installed so that water level observations can be made.

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SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 Design: No hydrologic or hydraulic design data was available for use in preparing this report.

5.2 Hydrologic Records: No rainfall or stream gage records are maintained at the dam site.

5.3 Flood Experience: The maximum flood of record at the dam site occurred during Tropical Storm Agnes, June 1972. During this storm the reservoir rose to a level of approximately 0.5 inch above the emergency spillway crest.

5.4 Flood Potential: Performance of the reservoir by routing the Probable Maximum Flood (PMF) and the 1/2 Probable Maximum Flood (1/2 PMF) is shown in Table 5.1. The flood potential of the reservoir was determined by utilizing the U.S. Army Corps of Engineers' Flood Hydrograph Package, HEC-1 DB, and appropriate unit hydrograph, precipitation, and storage-discharge data. The time of concentration (Tc) and Clark's R used in the analysis were estimated from drainage basin characteristics. The rainfall applied to the unit hydrograph was obtained from the U.S. Weather Bureau (Reference 5, Appendix VIII). Rainfall losses were estimated at an initial loss of 1.0 inch and a constant loss thereafter of 0.05 inch per hour.

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

Regulation of flow from Robertson Dam is automatic. The normal pool is maintained at elevation 145.0 feet by the principal spillway riser crest. When the capacity of the principal spillway is exceeded, water rises in the reservoir to elevation 147.0 feet. Above this elevation, water discharges through the emergency spillway. Reservoir area and storage capacity were determined by use of the 7.5 Minute USGS Quadrangle for Collierstown, Virginia. Outlet discharge capacity was computed including flow through the principal and emergency spillways. Flood routings were determined with initial reservoir level at normal pool.

5.6 Overtopping Potential: The probable rise in reservoir and other pertinent information on reservoir performance for the 1/2 PMF and PMF hydrographs are shown in the following table:

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TABLE 5.1 RESERVOIR PERFORMANCE

Item	Normal	Hydrographs 1/2 PMF	Hydrographs PMF(a)
Peak flow, c.f.s.			
Inflow	-	4850	9700
Outflow	-	4250	9060
Peak elev., ft.	145.0(b)	153.1	154.8
Emergency spillway (c) (elev. 147.0 feet)			
Depth of flow, ft.	-	6.1	7.8
Average velocity, f.p.s.	-	11.5	12.9
Duration of flow, hrs.	-	11.0	15.3
Non-overflow section (elev. 152.0 feet)			
Depth of flow, ft.	-	1.1	2.8
Average velocity, f.p.s.	-	2.8	4.4
Total duration of overtopping, hrs.	-	1.0	2.8
Tailwater elev., ft. (d)	95.4	-	-

(a) The PMF is an estimate of flood discharges that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in a region.
(b) Assumed datum from design plans.
(c) Depth and velocity estimates based on critical depth at control section.
(d) Tailwater at time of inspection.

5.7 Reservoir Emptying Potential: The reservoir can be drawndown by means of the 24 inch diameter outlet conduit. Flow through the conduit is controlled by an 18 inch square sluice gate manually operated from the riser tower. Neglecting inflow, the reservoir can be drawndown from normal pool in less than 5 days.

5.8 Evaluation: Robertson Dam is an "intermediate" size - "high" hazard dam requiring evaluation for a spillway design flood (SDF) equal to the PMF. The PMF was routed through the reservoir and found to overtop the dam by a maximum depth of approximately 2.8 feet with an average critical velocity of 4.4 f.p.s. Total duration of dam overtopping would be approximately 2.8 hours. The spillways are capable of passing only 35 percent of the PMF.

Conclusions pertain to present day conditions and the effect of future development on the hydrology has not been considered.

SECTION 6 - DAM STABILITY

6.1 Foundation and Abutments: Little information is available concerning the dam foundation. Sixteen shallow borings, less than 5 feet deep each, were drilled throughout the reservoir area (see Plate 2). Only boring number 1, which was advanced 5 feet, was drilled in the vicinity of the embankments and did not encounter bedrock. The site soils are only generally described as residual clays derived from weathering of the limestone bedrock. These clays are reported to have "very high liquid limits and plastic indexes and are difficult to control and compact" (see page 2 of 17 and 18 March 1972 Inspection Report in Appendix V).

The abutment areas consist partly of thin bedded and fractured limestone outcrops which dip approximately 45 percent into the dam. The remainder of the abutment areas appear to be covered by a thin mantle of residual clay over limestone. The limestone in the area of the dam may be cavernous. Solution cavities exist in the spillway outcrop. Numerous sinkholes are shown in the vicinity of the dam on the 1967 USGS 7.5 minute topographic quadrangle map, Collierstown, Virginia. Bedrock in this area consists completely of Upper and Middle Ordovician limestone formations.

6.2 Stability Analysis

6.2.1 Visual Observations: Slumping in the downstream embankment has occurred in the past and was repaired. Presently, sloughing is apparent in two areas on the downstream embankment which can be attributed to seepage, surface runoff, and possibly animal burrows as described in detail in Section 3.1.2. Seepage under the clay core from the reservoir was suspected in 1972 when sliding initially occurred, but this was not proven by the 1972 inspection. Seepage was observed emmanating from the limestone which outcropped in the right abutment during repairs to the 1972 slide.

Although the major area of seepage and instability are in the area of the right downstream slope, minor slumping and seepage was also noted approximately halfway up the left junction of the downstream embankment slope with the emergency spillway discharge channel.

6.2.2 Design Data: No stability analyses, or soils laboratory data, or construction details were available for this evaluation. It appears that the possibility of cavernous limestone underlying the dam was not considered in the dam design in view of the limited boring data.

The typical section for the embankment shows a uniform 2.5:1 downstream slope. The upstream slope, from the toe to elevation 145.0 feet, was designed at a 3:1 ratio. Above the 4 foot berm at elevation 145.0 feet, 2.5:1 slopes were specified. The crest width is 8 feet.

The clay core of the dam (Zone 1 on Plate 2) is seated in a key way approximately 3 feet deep. From available information, it appears that the core and the embankment are built on the clay soils described above.

As shown in Appendix VI, 100 percent maximum density was required by the specifications for embankment compaction.

6.2.3 Operating Records: Reports of stability problems, evaluations, and subsequent corrective measures are included in Appendix V. It is reported by park personnel that the maximum reservoir level occurred during floods associated with Tropical Storm Agnes on 19 and 20 June 1972. Approximately 0.5 inch of water flowed across the emergency spillway crest at that time.

6.2.4 Post-Construction Changes: With the exception of the repairs to the slide which occurred in 1972, no alterations to the dam or major changes are apparent.

6.2.5 Seismic Stability: Robertson Dam is situated in Seismic Zone 2, which is considered a non-hazardous earthquake zone according to the Recommended Guidelines for Safety Inspection of Dams, provided static stability conditions are satisfactory and conventional safety margins exist.

6.3 Evaluation: According to available evidence, the seepage, which is primarily responsible for the sliding that has occurred in the downstream embankment near the

abutments, originates from the limestone outcrops in the abutment areas. However, some of the slumping which occurred in 1972 was reportedly the result of Tropical Store Agnes. The possibility of additional minor sliding, considering the continued seepage and poor surface drainage conditions described in Section 3.1.2, is high without the installation of seepage relief drains and other site improvements. It is likely that the limestone in the abutments is cavernous and solution channels may be enlarged over time. If installed, the seepage relief drains recommended in Section 3.2 should be monitored periodically for flow increases which would indicate a deteriorating condition.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment: Several conditions discovered during the field investigation and office analyses indicate deficiencies requiring additional attention. The zone of sloughing at the junction of the downstream slope with the right abutment is considered the most serious problem. Clear seepage through the embankment in this area is causing slumping of the embankment material. Previous inspections (see Appendix V) indicate that this seepage has occurred since 1972. Repairs made in the fall of 1972 were considered as "temporary measures." The presence of more recent sloughing indicates that the temporary measures instituted in 1972 are not sufficient to stabilize the embankment over a long time period. Therefore, more extensive remedial measures must be considered.

Using the Corps of Engineers' screening criteria for initial review of spillway adequacy, the PMF was selected as the SDF for the "intermediate" size - "high" hazard classification of Robertson Dam. The PMF was routed through the reservoir and found to overtop the dam by a maximum depth of 2.8 feet with an average critical velocity of 4.4 f.p.s. Total duration of dam overtopping would be approximately 2.8 hours. The combination of the instability of the downstream embankment at the right abutment and the seriously inadequate spillways represent a higher potential for dam failure during overtopping of the embankment crest. The spillways are capable of passing only 35 percent of the PMF, and are therefore considered seriously inadequate. The dam is assessed as unsafe, non-emergency.

The relative narrow crest (8 feet wide) of embankment would not offer good resistance to erosion during overtopping even though it is covered with a good stand of grass. Since the seepage from the downstream embankment at the right abutment is not usually high (estimated at 0.8 g.p.m.) and no piping was evident, the sloughing in this area may indicate a more serious potential of embankment instability, such as sliding. Sufficient geologic and soil data was not available to evaluate the embankment stability.

The other deficiences discovered during the field investigation, although important, are not considered urgent and may be accomplished as part of the general maintenance of the dam. These deficiencies and recommended remedial measures are listed in Section 7.2.

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7.2 Recommended Remedial Measures: It is recommended that within two months of the date of notification of the Governor of the Commonwealth of Virginia, that the owner engage the services of a professional engineering consultant to:

1) Determine the stability of the upstream and downstream slopes, especially in the area of sloughing at the junction of the right abutment and downstream embankment.

2) Determine by more sophisticated methods and procedures the adequacy of the spillways. The study should include a more detailed study of the downstream floodplain and of the spillway design flood appropriate to this dam. Remedial measures to be considered include modification of the dam, spillway, floodplain, and/or any other method of eliminating the danger imposed by the project.

Within six months of the notification of the Governor, the consultant's report of appropriate remedial mitigating measures should have been completed and the owner should have an agreement with the Commonwealth of Virginia for a reasonable time frame in which all remedial measures will be complete.

Until corrective measures are completed the dam should be checked during periods of heavy runoff. The flow from the weep at the toe of the embankment near the right abutment should be periodically checked and recorded. Monitoring of the flow rate and turbidity is recommended. If evidence of piping of embankment material, further sliding of the embankment, or if dam overtopping is imminent warning should be issued to the downstream inhabitants.

In the interim, an emergency operation and warning plan should be promptly developed. It is recommended that a formal emergency procedure be prepared, prominently displayed, and furnished to all operating personnel. This should include:

1) How to operate the dam during an emergency.

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

3) Procedures to evaluate inflow during periods of emergency operation.

The following items can be accomplished as part of the general maintenance of the dam:

1) Excavate, fill, compact, and seed rodent holes in the embankment.

2) Repair the corner of the concrete apron near the outlet pipe.

3) Excavate, fill, compact, and seed the slumped area at the junction of the embankment and the emergency spillway discharge channel. Also, provide riprap in the gutter to prevent erosion from surface runoff.

4) Add additional riprap on right end of the upstream embankment to prevent erosion.

5) Remove small trees from the embankment and emergency spillway.

6) Repair and seed erosion damage on the embankment and emergency spillway.

7) Install a staff gage to monitor reservoir levels above normal pools.

APPENDIX I

PLATES

CONTENTS

Location Plan

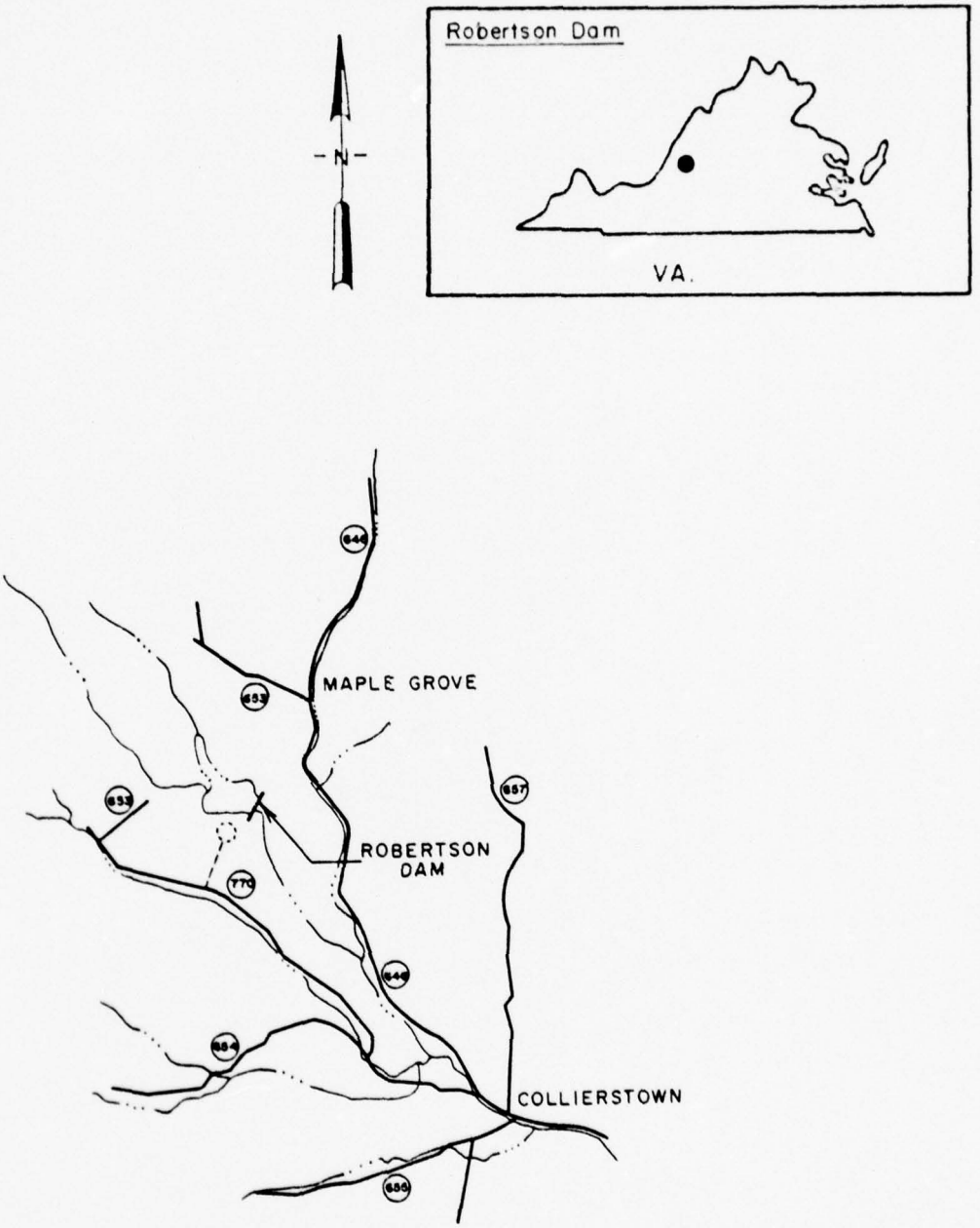
Plate 1: Field Sketch

Plate 2: Plan and Typical Profiles

Plate 3: Head Tower Details and Plan for Grading of Emergency Spillway

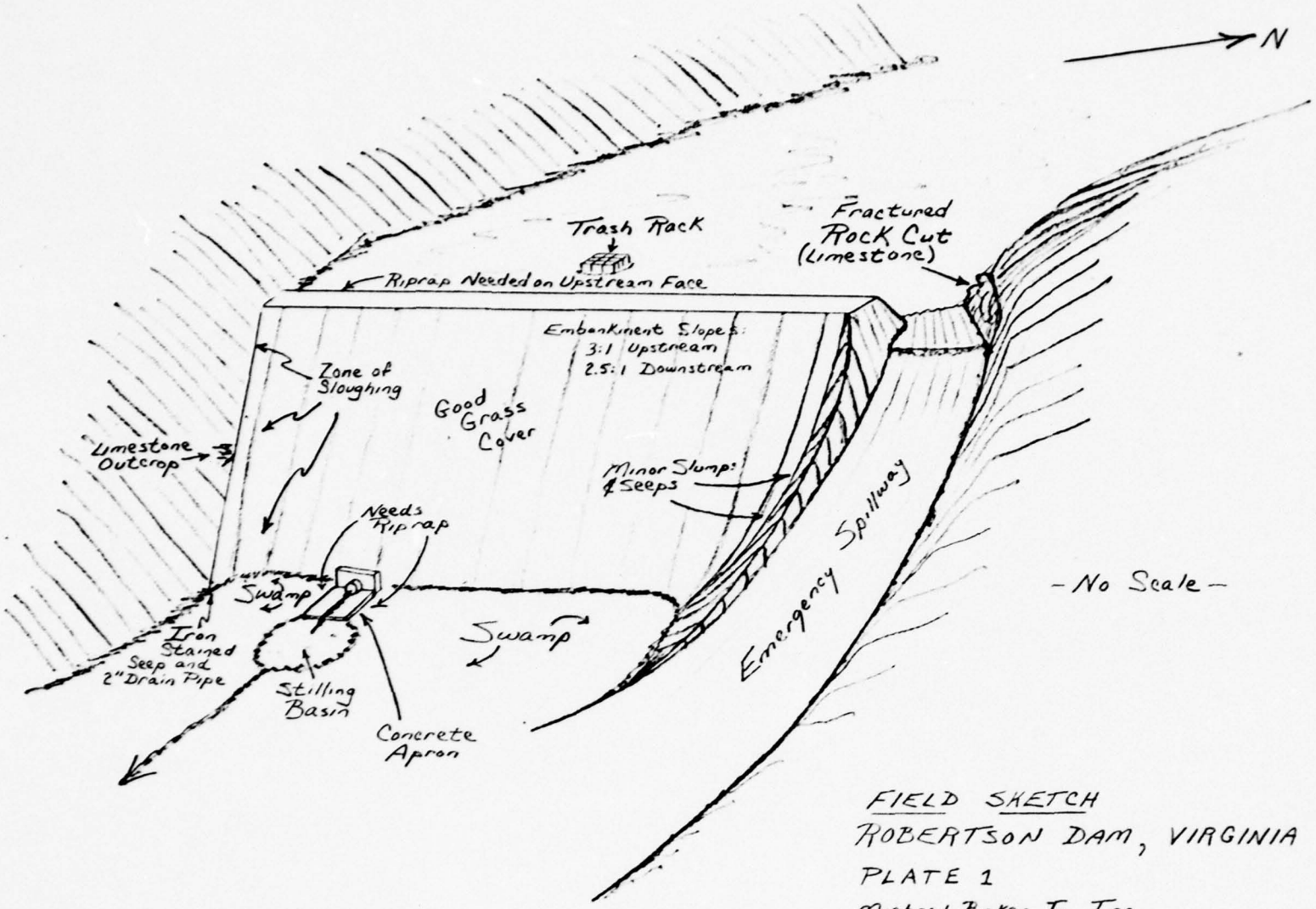
Plate 4: Head Tower Construction Drawings

NAME OF DAM: ROBERTSON DAM

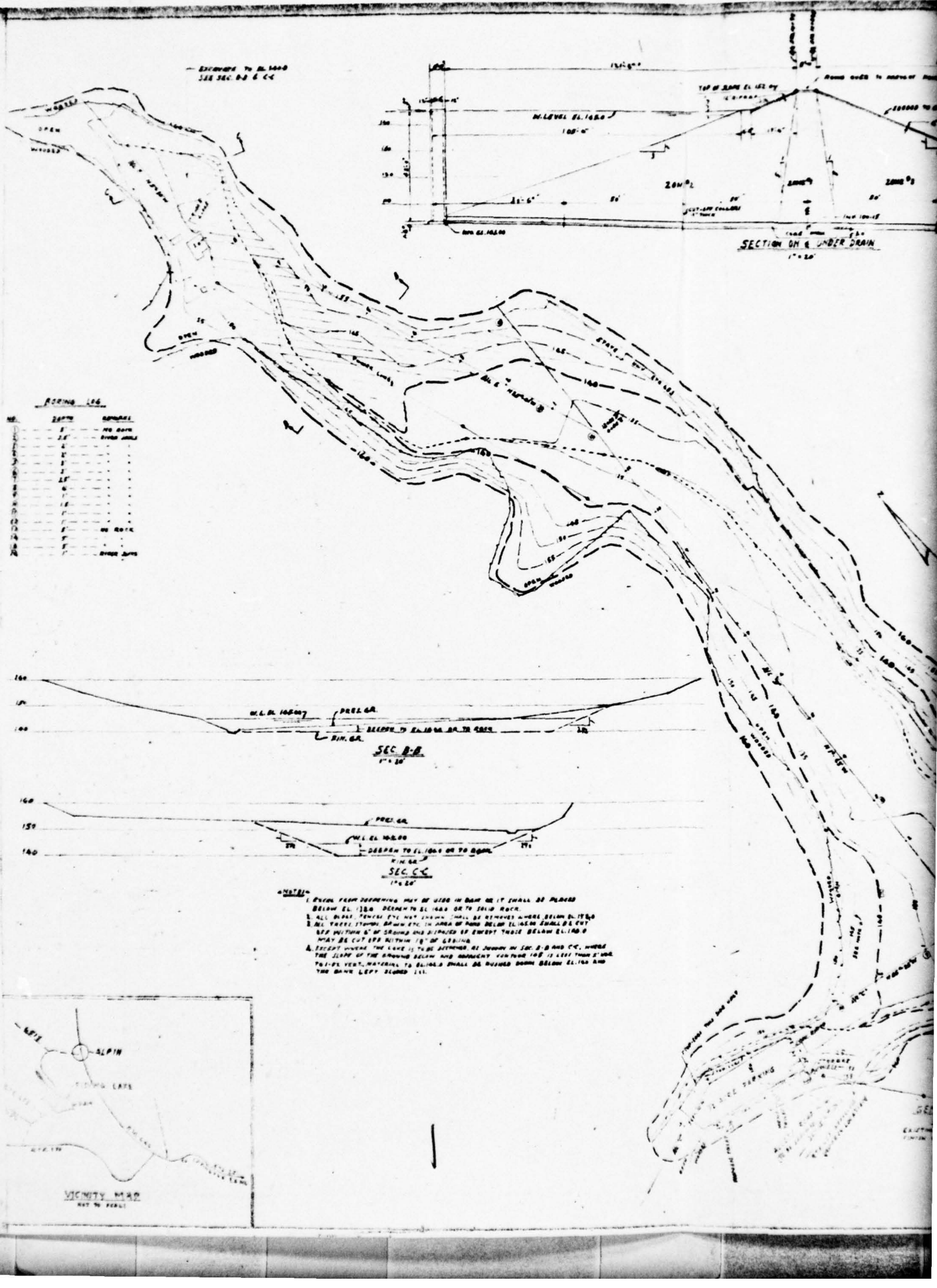


LOCATION PLAN

ROBERTSON DAM



FIELD SKETCH
ROBERTSON DAM, VIRGINIA
PLATE 1
Michael Baker, Jr., Inc.
5 June 1979


EXCAVATE TO EL 1660
SEE SEC. B-B & C-C
SECTION ON & UNDER DRAIN
BORING LOG
SEC B-B
SEC C-C
NOTES:
VICINITY MAP

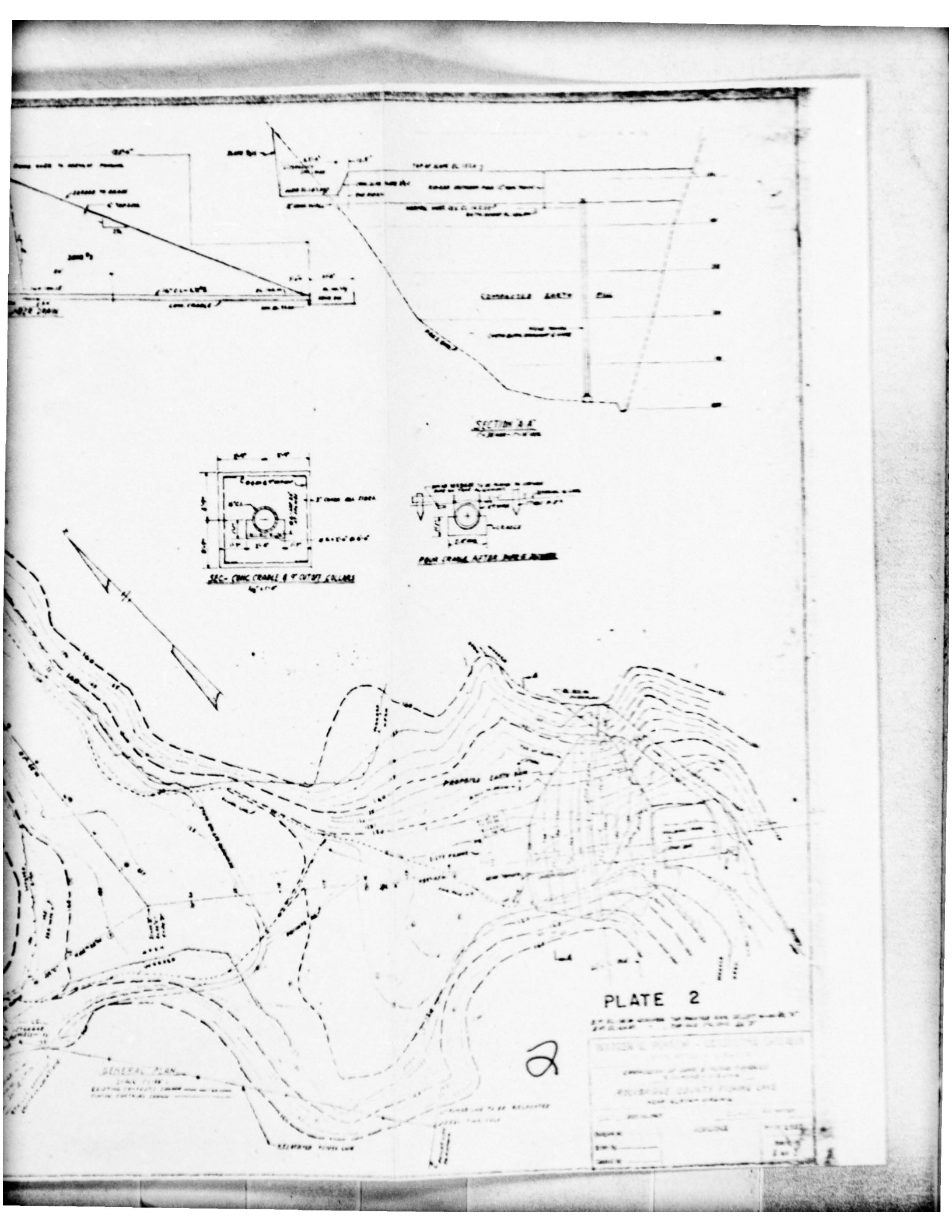
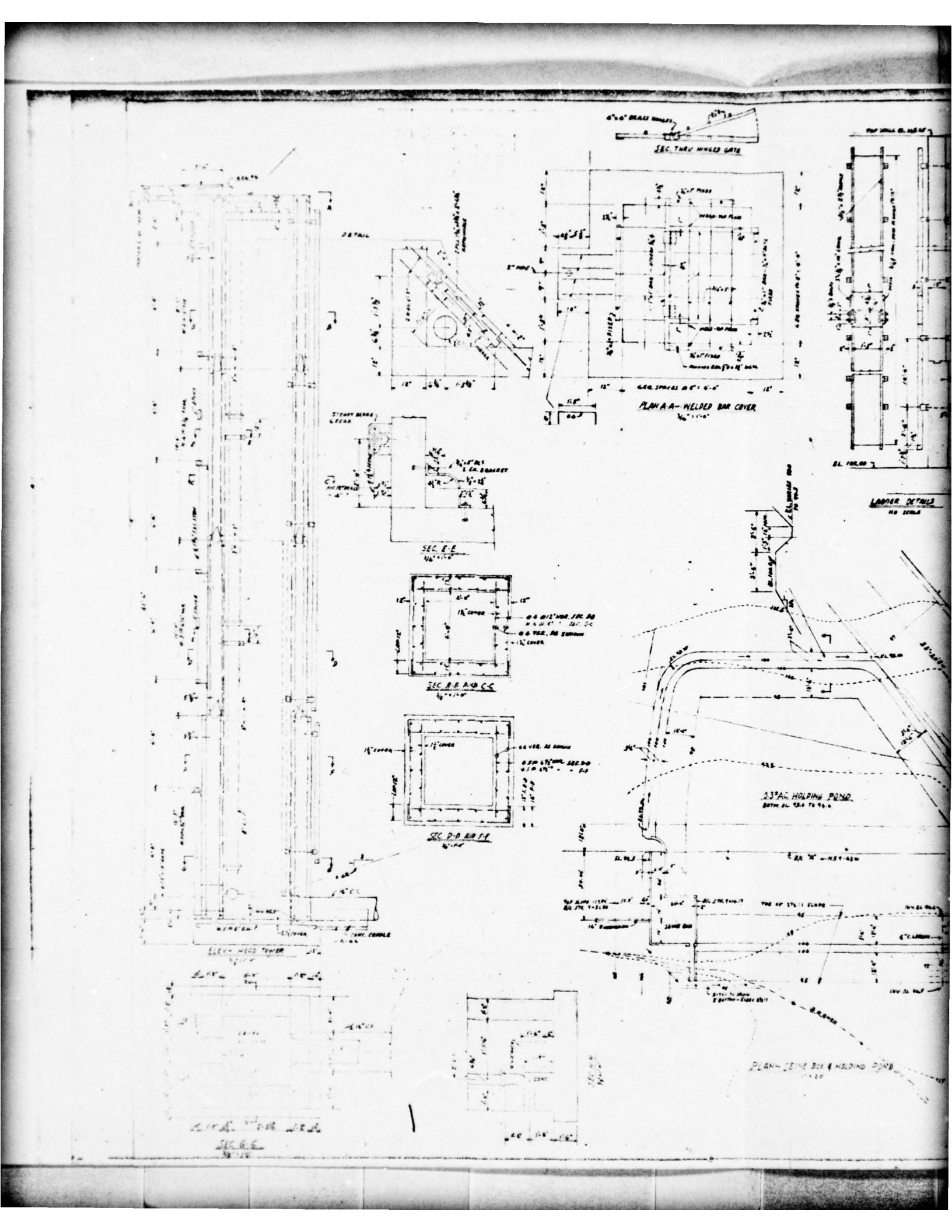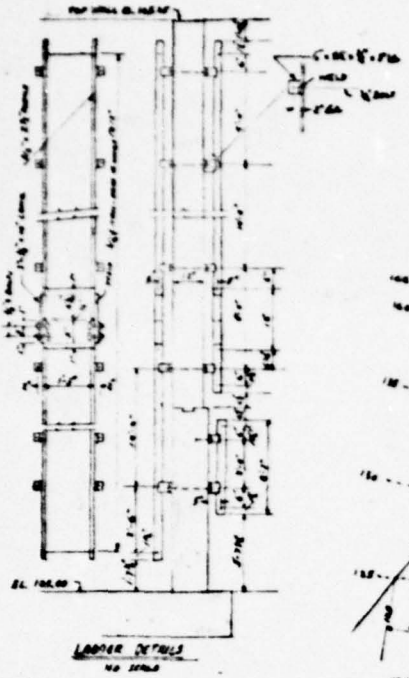
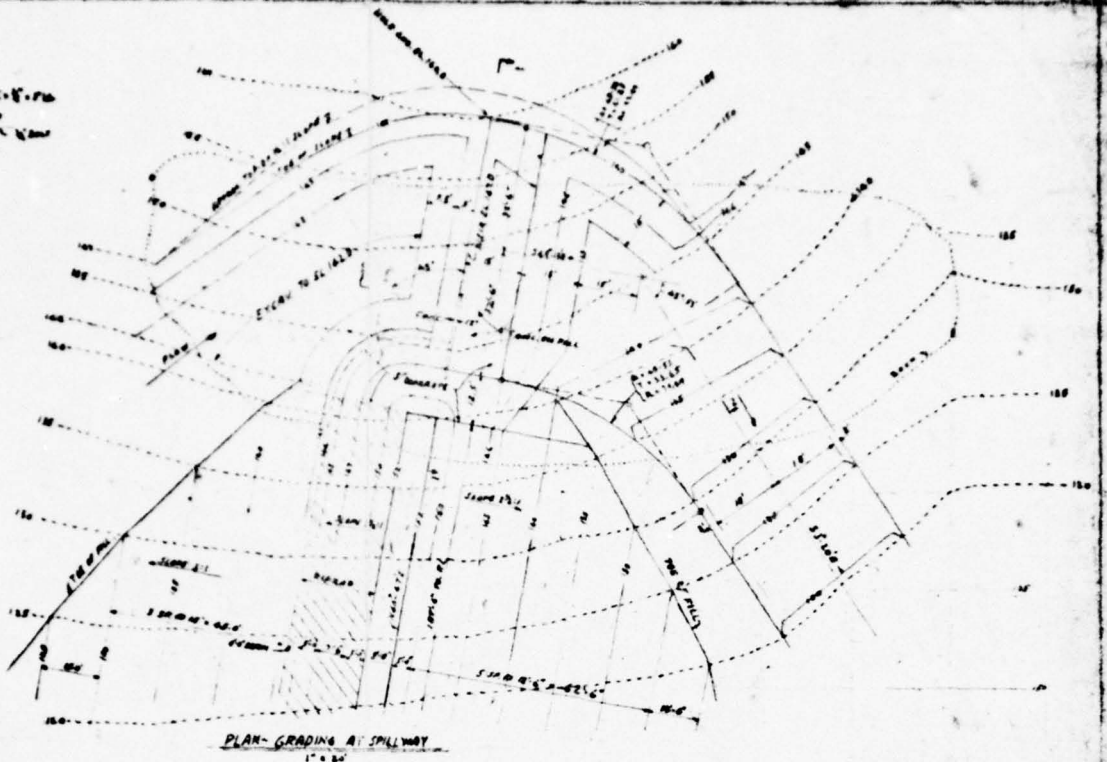
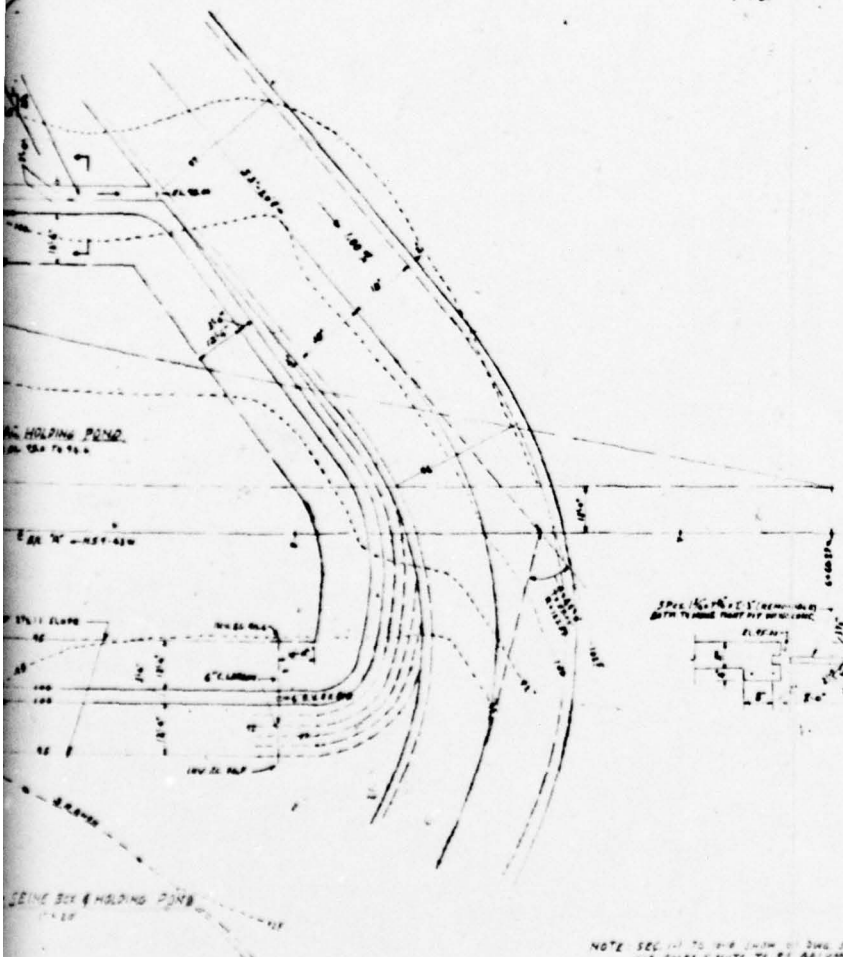


PLATE 2


SEC. THRU HINGED GATE
PLAN A-A- WELDED BAR COVER
LADDER DETAILS
SEC. E-E
SEC. B-B AND C-C
SEC. D-D AND F-F
ELEV- HEAD TOWER
SEC. G-G
0.33 AC. HOLDING POND
PLAN- SEINE BOX & HOLDING POND







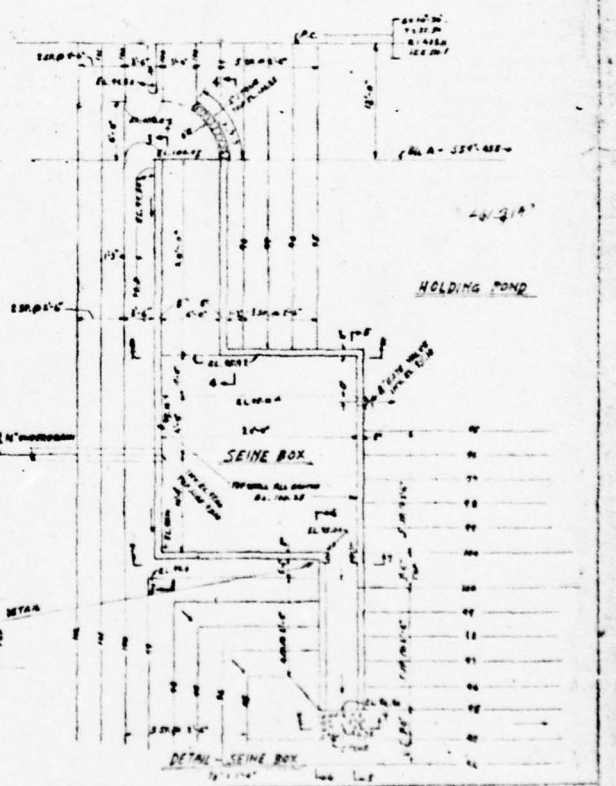
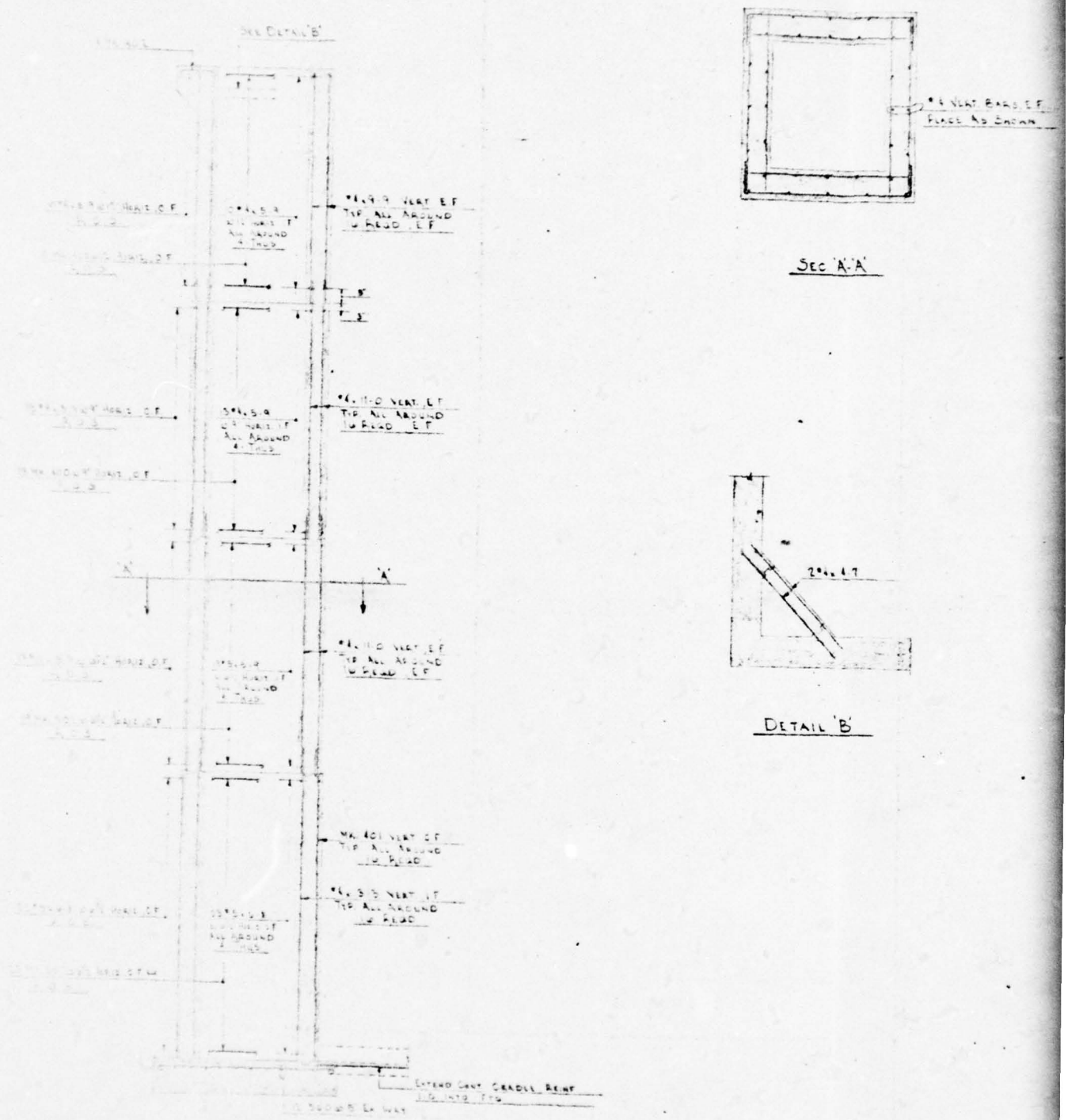


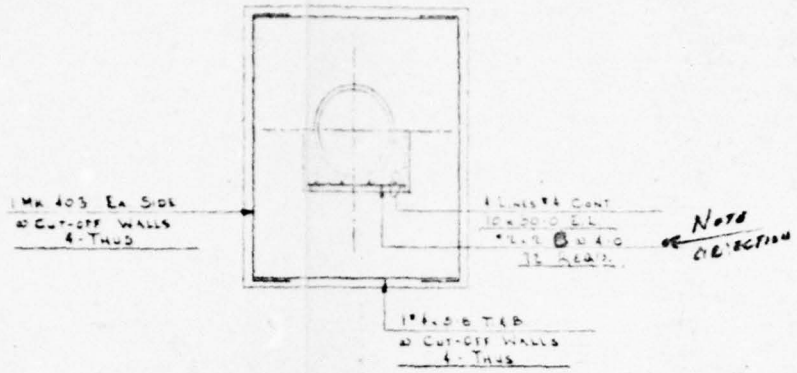
PLATE 3

NOTE: SEE SHT. 1 OF THIS SET OF DWGS. FOR ALL BOLTS & NUTS TO BE GALVANIZED

ROCKBRIDGE COUNTY FISHING LAKE
NEAR ALBERTA, VA.

2 of 2


SEE DETAIL 'B'
#6 VERT BARS E.F.
PLACE AS SHOWN
SEC 'A-A'
2#6 E.F.
DETAIL 'B'
EXTEND CONT CRADLE REINF



Sec - Conc Cradle & 9' Cut-Off Walls

2

PLATE 4

ABBREVIATIONS

Alt.	- Alternate
B.	- Bottom
D.	- Diameter
E.E.	- Each End
E.F.	- Each Face
E.S.	- Each Side
E.W.	- Each Way
F.O.W.	- Face of Wall
N.F.	- Near Face
N.I.C.	- Not In Contract
O.F.	- Opposite Face
S.W.	- Shear Wall
T.	- Top
U.N.O.	- Unless Noted Otherwise
V.	- Varies
W.P.	- Working Point
X.O.E.	- Equal Opposite Side

VALLEY STEEL CORPORATION

PROJECT

LOCATION

APPROVED

DRAWING NO. V69-1760 SHEET NO. 1 OF 1

REVISED

APPENDIX II

PHOTOGRAPHS

CONTENTS

Photo 1: Principal Spillway Head Tower with Sluice Gate Hand Crank

Photo 2: Slopes and Vegetation Surrounding Reservoir

Photo 3: Principal Spillway Outlet and Stilling Basin

Photo 4: Upstream View of Emergency Spillway

Photo 5: Right Downstream Embankment Slide Area and Swamp

Photo 6: Two Inch Diameter Plastic Drain Pipe Outlet

Photo 7: View of Downstream Channel from Dam Crest.

Note: Photographs were taken on 5 June 1979.

NAME OF DAM: ROBERTSON DAM

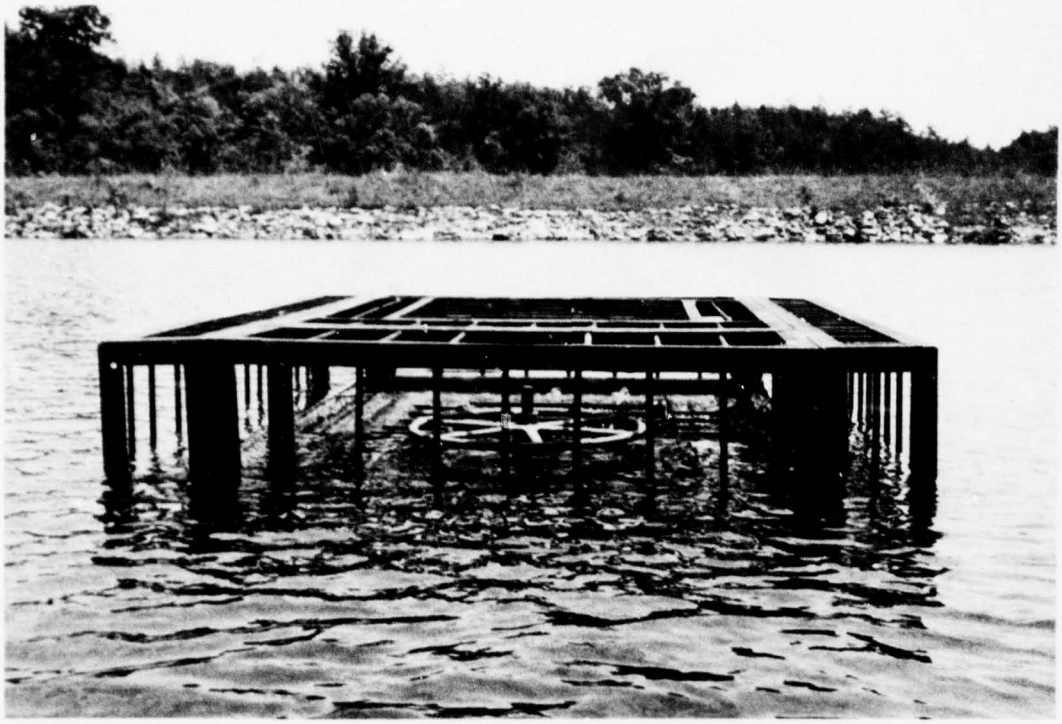


PHOTO 1. Principal Spillway Head Tower with Sluice Gate Hand Crank

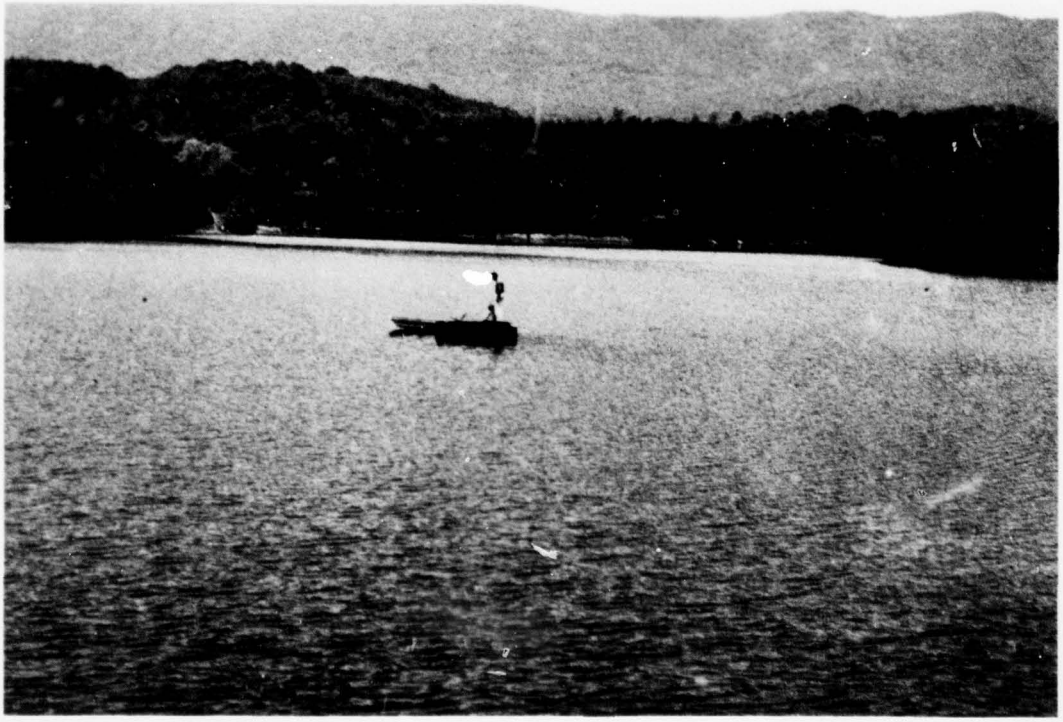


PHOTO 2. Slopes and Vegetation Surrounding Reservoir

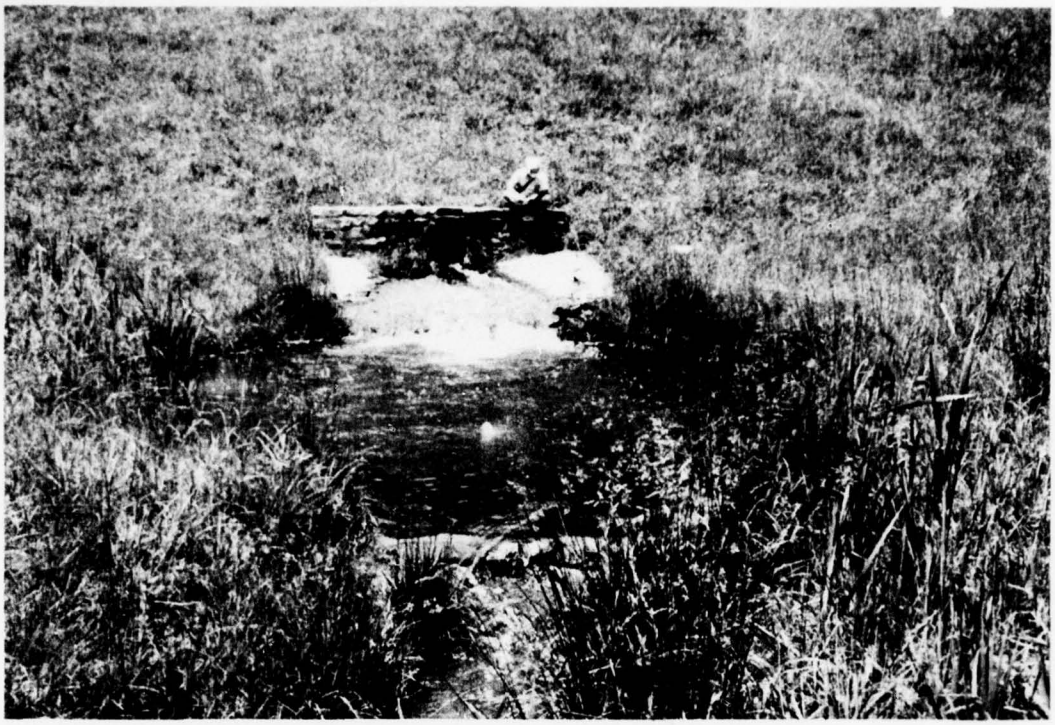


PHOTO 3. Principal Spillway Outlet and Stilling Basin



PHOTO 4. Upstream View of Emergency Spillway



PHOTO 5. View of Downstream Channel from Dam Crest



PHOTO 6. Two Inch Diameter Drain Pipe Outlet

ROBERTSON DAM



PHOTO 7. Right Downstream Embankment Slide Area and Swamp

APPENDIX III

CHECK LIST - VISUAL INSPECTION

Check List
Visual Inspection
Phase 1

Name of Dam Robertson Dam County Rockbridge State Virginia Coordinates Lat. 3748.2
Long. 7936.4

Date of Inspection 5 June 1979 Weather Sunny Temperature 80°F.

Pool Elevation at Time of Inspection 145.77 Assumed Datum
Tailwater at Time of Inspection 95.4 Assumed Datum

Inspection Personnel:

Michael Baker, Jr., Inc.:

T. W. Smith
R. E. Holderbaum
D. W. Hupe

Owner's Representatives:

Donald Firebaugh
Lloyd Byrd

Virginia Water Control Board:

Hugh Gildea

D. W. Hupe Recorder

EMBANKMENT

Name of Dam: ROBERTSON DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	A 20 ft. wide zone of sloughing extends from the dam crest to the toe on the right downstream near the abutment. Surface water drainage at the junction of the embankment and the abutment near this slide zone is not channeled adequately and this water spreads across the slide zone. Minor sloughage was observed on the downstream embankment next to the discharge channel of the emergency spillway. Surface drainage is poor in this area. A few animal burrows are present.	Sandy fill was brought in to repair the sloughage on the downstream embankment. A 2 in. dia. plastic drain pipe was placed within the right slide area to attempt to relieve water build-up (discharging approximately 0.8 g.p.m. clear water).
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Vertical variation along the crest of the dam is only about 0.5 ft. The horizontal alignment has a slight curvature toward the lake as observed in the field and indicated on the plans.	
RIPRAP FAILURES	Existing riprap is generally satisfactory.	Additional riprap should be placed around the outlet pipe and around the upstream sides of the stilling basin to protect the toe of the embankment. More riprap should be placed on the upstream embankment on the right end of the dam.

EMBANKMENT

Name of Dam: ROBERTSON DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
VEGETATIVE COVER	A good cover of grass exists on the downstream face of the dam. A few small trees have rooted.	Remove the trees.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Sloughing was observed in the downstream embankment near the junctions of the embankment with the abutments. A 1 ft. deep gully has formed on the right downstream embankment/abutment junction. A dense, 3 ft. high grass cover has minimized the potential erosion. Riprap was not used along the junctions of the abutments with the embankment.	Underdrains should be installed in the downstream embankment/abutment junction areas. Good surface drainage should be reestablished in these areas and riprap placed to prevent erosion.
ANY NOTICEABLE SEEPAGE	An iron-stained seep (less than 2 g.p.m.) is present at the toe of the right downstream embankment. Also, drainage occurs from the 2 in. dia. drain pipe extending into the zone of sloughing above the iron-stained seep. These seeps form a swampy zone at the right toe of the dam. A 2500 sq.ft. swampy area is present on the left side of the outlet pipe. This area is not produced by a point discharge but appears to be the result of poor drainage. This area correlates with a holding pond area shown on the original design plans which was not developed. Minor seeps occur on the left downstream embankment adjacent to the emergency spillway in the area of the small slumps.	Limestone bedrock outcrops are indicated on the original plans in the areas where embankment sloughing has occurred. Bedrock springs may have initiated the sloughing. Underdrains as explained above, should relieve water buildup.
STAFF GAGE AND RECORDER	None present	A staff gage should be installed.
DRAINS	None included in dam design.	

EMBANKMENT

Name of Dam: ROBERTSON DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
OTHER NOTES	According to the state geologic map and visual observations, the entire area is underlain by limestone bedrock. Numberous local sinkholes are indicated on the USGS 7.5 min. topographic map. Sinkholes were not observed in the areas adjacent to the dam abutments. However, the limestone exposed in the bedrock cut of the emergency spillway is highly fractured and 2 small cavernous areas were detected. There is no indication from the available design plans that exploratory drilling was conducted to determine if the limestone in the vicinity of the dam is cavernous.	

OUTLET WORKS

Name of Dam: ROBERTSON DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
OUTLET CONDUIT	The outlet conduit is a 24 in. C.I.P. The conduit, at its exit, appeared to be in satisfactory condition.	
INTAKE STRUCTURE	Intake structure consists of a reinforced concrete riser with welded steel trash rack at the top. The concrete at the crest of the riser is spalling but does not deter proper operation of the riser.	
OUTLET STRUCTURE	The northeast corner of the concrete apron at the dam outlet has deteriorated slightly. There is insufficient riprap around the outlet pipe and especially around the upstream sides of the stilling basin.	Additional riprap should be placed around the outlet and stilling basin.
OUTLET CHANNEL	The outlet channel is generally unobstructed.	
EMERGENCY GATE	An 18 in. sluice gate, manually operated from the top of the riser, may be used to drain the reservoir.	

NIDIS

UNGATED SPILLWAY

Name of Dam: ROBERTSON DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONTROL SECTION	A small portion of the level section in the spillway is covered with a concrete slab. No deterioration was observed.	
APPROACH CHANNEL	The approach channel has several small trees which should be removed.	
DISCHARGE CHANNEL	Some slight erosion has occurred and a few areas are unvegetated. The discharge channel slope exceeds 10%.	Periodic repair of erosion and seeding of unvegetated areas should be conducted.
BRIDGE AND PIERS	Not Applicable	

INSTRUMENTATION

Name of Dam: ROBERTSON DAM

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	Permanent markers could not be located.	
OBSERVATION WELLS	None observed	
WEIRS	None observed	
PIEZOMETERS	None observed	
OTHER		

RESERVOIR

Name of Dam: ROBERTSON DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Slopes are steep but appear stable. A good tree cover has helped to stabilize the slopes.	
SEDIMENTATION	Very minor sedimentation is evident.	

DOWNSTREAM CHANNEL

Name of Dam: ROBERTSON DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	The valley is fairly wide. Tree cover is fairly dense beginning approximately 500 ft. downstream of the toe area.	
SLOPES	The downstream channel is moderately sloping from the dam to the community of Collierstown.	
APPROXIMATE NO. OF HOMES AND POPULATION	An estimated 4 or 5 homes are situated in low-lying areas in the community of Collierstown, approximately 1.5 mi. downstream from the dam.	

APPENDIX IV

CHECK LIST - ENGINEERING DATA

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

Name of Dam: ROBERTSON DAM

ITEM	REMARKS
PLAN OF DAM	The Plan of Dam is included in this report as Plate 2.
REGIONAL VICINITY MAP	The vicinity map is presented in this report as the Location Plan.
CONSTRUCTION HISTORY	The dam was designed by Warren C. Perrow-Consulting Engineer, Richmond, Virginia. The dam was constructed by Charles W. Barger and Son Construction Co., Inc. of Lexington, Virginia in 1970. Inspection during construction was done by Hayes, Seay, Mattern, and Mattern Architects and Engineers of Roanoke, Virginia.
TYPICAL SECTIONS OF DAM	Typical sections of the dam are included in this report as Plate 2.
HYDROLOGIC/HYDRAULIC DATA	No hydrologic or hydraulic data was available for review.
OUTLETS - PLAN and DETAILS	Included on the plates incorporated in this report.
- CONSTRAINTS and DISCHARGE RATINGS	Developed as part of this report.
RAINFALL/RESERVOIR RECORDS	None were available at the dam site.

Name of Dam: ROBERTSON DAM

ITEM	REMARKS
DESIGN REPORTS	Design plans and specifications were obtained from the owner.
GEOLOGY REPORTS	None available
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Shallow (less than 5 ft.) borings were drilled in reservoir area according to design plan. No deep borings were indicated in the immediate area of the dam. Materials encountered were not described or tested according to available information.
POST-CONSTRUCTION SURVEYS OF DAM	No known post-construction surveys have been done.
BORROW SOURCES	According to the design specifications, all borrow was to be acquired within the reservoir area from excavations.

Name of Dam: ROBERTSON DAM

ITEM	REMARKS
MONITORING SYSTEMS	No monitoring systems have been provided.
MODIFICATIONS	The holding pond and seine box shown on the original design plans were not constructed.
HIGH POOL RECORDS	Highest pool was experienced in 1972 during Agnes when approximately 0.5 in. of water flowed across the crest of the emergency spillway.
POST-CONSTRUCTION ENGINEERING STUDIES AND REPORTS	See below.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	Slumping occurred in the right downstream embankment twice in 1972. Engineering investigations and description of corrective measures are included in Appendix V of this report.
MAINTENANCE OPERATION RECORDS	None available

Name of Dam: ROBERTSON DAM

ITEM	REMARKS
SPILLWAY SECTIONS and DETAILS	A section is included on Plate 2 of this report. Spillway details are included on Plate 3 of this report.
OPERATING EQUIPMENT PLANS & DETAILS	Details for the 18 in. sq. sluice gate are included on Plate 3 of this report.

APPENDIX V

FIELD INSPECTION REPORTS

SINCE 1881

FROEHLING & ROBERTSON, INC.

INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS

CABLE ADDRESS—"FROEHLING"

MAIN OFFICE AND LABORATORIES
P. O. BOX 27324, RICHMOND, VIRGINIA
PHONE 643-3221

BRANCH LABORATORIES
NORFOLK, CHARLOTTE, RALEIGH
WASHINGTON, BALTIMORE
GREENVILLE, ROANOKE, FAYETTEVILLE
ASHEVILLE

Richmond, Virginia
March 27, 1972

Report No. X-1871-3

Report of: Field Inspection Trip

Made for: Commission of Game and Inland Fisheries
4010 West Broad Street
Richmond, Virginia
Attn: Mr. Garret Scott

Date Made: March 17 & 18, 1972

Upon authorization from Mr. Garret Scott of the Commission of Game and Inland Fisheries, the writer made a field inspection trip to the site of the Rockbridge County Fishing Lake. The lake is located approximately 9 miles west of Lexington, Virginia on Route 653, between Route 670 and Route 646 at Alpin, Va.

The writer was asked to visit the site in order to investigate a soil slump in the N.W. downstream abutment of the earth fill dam.

The area of the partial failure of soil in the dam was visually inspected by the writer on March 17 and 18, 1972. The soil movement in the downstream portion of the dam showed the typical soils cross section of a Swedish Circle Shear Failure. For this type of accurate failure to occur the shear strength of the soils in place must first be overcome. Water is usually a factor in 95% of this type of slides affording lubrication to the Solem (plane of movement) as well as reducing the shear strength of the soils in place.

There are probably three factors that enter into this failure in increasing order of importance they are as follows:

1. Lack of Proper Internal Drainage in the Dam

   With proper drainage the phreatic line through the dam is greatly lower on the downstream side thus increasing its shear strength. (That is, resistance to horizontal displacement) The total stress in the dam is reduced to only effective stress above the water table with proper drainage. Thus as settlement occurs in a soil dam the area in which pore water pressures can build up (neutral stress) is greatly reduced.

   The total end result is that with proper internal drainage the water table is lower towards the downstream face of the dam and the possibilities of shear failure are greatly reduced.

2. Selection of Construction Materials & Resultant Low Degree of Compaction

   The insitu construction material available are residual soils derived mainly

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from the inplace weathering of the local limestone formations. These limestone clays have very high liquid limits and plastic indexes and as a result are difficult to control and compact. It is very doubtful that the 100% compaction of AASHO T-99 as called for was ever achieved or could be achieved with these materials.

The lower the percent of compaction achieved, the greater the settlement potential of the soils in question and also the lower the shear strengths.

3. Dip of Rock in the Abutments of the Dam

The dip of the thin bedded limestone formation in the abutments of the dam show a 45% dip into the dam. Limestone formations are subject to solution by ground water movement. Solution cavities could underlie the site and ground water can also move along the bedding planes of the rock. This, in the writer's judgment, is the major contributing factor to the noted soil shear failure.

Field vane shear test of the soil taken with hand operated equipment showed the average shear strength in the soils above the slide area to be 1500 lbs per sq. ft. This is low for supposedly compacted soils and would be equal to a 5-6 blow clay with the standard penetration test.

Vane shear readings in the disturbed area of the slide ranged from 0 to 700 lbs per sq.ft. Judging from the above results water under head from the reservoir area is moving into the soils below the clay core and have produced the noted shear failure slide.

Conclusion

We do not feel that the dam is in any danger of failure though the combination of the three conditions have produced a less stable soil condition than anticipated by the construction specifications.

We do advise that corrective measures be taken to stabilize the general area of the abutments. On a temporary basis we suggest the sand bagging of each abutment starting with the toe of the slope and working up.

The natural siltation that occurs in a reservoir may act to seal the avenues of water movement making any further repairs unneccessary. The abutments should be closely observed over the summer for indication of continued water movement and resultant loss of fines. If the water seepage remains clear and gradually ceases over the summer the problem may be self solving.

We hope we have supplied the requested data. If you have any questions please feel free to contact the writer.

Very truly yours,

FROEHLING & ROBERTSON, INC.

W. H. Vogelsang

V-2

W. H. Vogelsang, Director
Foundation Investigation

WHV/dw

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ASHEVILLE

Richmond, Virginia
July 5, 1972

Report No: X-1871

Report of: Field Inspection Trip

Made for: Commission of Game and Inland Fisheries
4010 West Broad Street
Richmond, Virginia
ATTN: Mr. Garret Scott

Date made: June 26, 1972

At the request of Mr. Garret Scott, the writer visited Willis Robertson Lake in Rockbridge County in order to investigate a soil slump in the SW abutment of the earth-fill dam.

The area of the partial failure of the soil in the dam was visually inspected by Mr. W. H. Vogelsang on March 17 and 18, 1972, and a report issued to the Commission of Game and Inland Fisheries on March 27, 1972. The purpose of the writer's visit on June 26, 1972, was to visually inspect additional slumping resulting from the rains during tropical storm Agnes June 19 and 20, 1972.

Additional slumping, approximately one cubic yard in volume, was apparent at the time of inspection. The recently slumped material was a soft, wet, sticky mass which had flowed over the top of the previously slumped material. Reactivation of the slump appears to hold no immediate danger to the dam structure; however, remedial action should be taken immediately which should include removal of the slumped material, replacement with properly compacted dry fill and sand-bagging of each abutment starting with the toe and working upward. The sand bags should be filled with free-draining sand.

We hope we have supplied the requested data. If you have any questions please feel free to contact the writer.

Very truly yours,

FROEHLING AND ROBERTSON, INC.

W. H. Duhling

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Richmond, Virginia
October 2, 1972

Report No. X-1871

Report of: Field Inspection Trip

Made for: Commission of Game and Inland Fisheries
4010 West Broad Street
Richmond, Virginia
Attn: Mr. Garret Scott

Location: Willis Robertson Lake
Rockbridge County, Va.
Date Made: September 25, 1972

As requested by Mr. Garret Scott of the Commission of Game and Inland Fisheries, a field trip was made to Willis Robertson Lake in Rockbridge County to inspect repairs being made to a slide area in the S.W. abutment of the Earth Fill Dam.

In the area of slide the earth fill for the dam had been removed down to bedrock and a small flow of water from the ledge rock had been exposed. The flow of water from the bedding plane of the Limestone Formation was probably the prime cause of the soil slump in the dam. The water flowing from the rock averaged about 1/2 gallon per minute. The water was clear and cold in contrast to the water leaving the lake through the spillway. This water was cloudy and odiferous.

Due to the dip of the ledge rock in the abutments of the dam at a 45% angle towards the dam, it was difficult to visualize another source for this water than the lake. The topography of the area is such that it would not seem probable that sufficient head and intake area could be involved to account for the permanent flow recorded in the S.W. abutment. Some other source for the water is possible but not probable.

Mr. Milton Adams, who is supervising the repair work, suggested that a "weep" be installed with the discharge routed away from the abutment. After installation of the "weep", the excavated area of the slump would be refilled with compacted soil and then sand bagged as previously recommended. This remedial step would be acceptable as a probable temporary measure.

We suggest the weep hole flow be watched for change in volume or water color. If the flow of water is continuous and increases in volume and becomes cloudy, it will probably mean that bedding planes and joints are being flushed out. If this is the case, other areas of the rock could be expected to start acting as waterways. Water irregardless of the source coming out with some head from the ledge rock would represent a danger to the stability of the dam.

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We suggest that another field inspection trip be made after the completion of current repairs so that an assessment of weep can be made so that the need for more permanent repairs can be assessed.

Thank you.

Very truly yours,

FROEHLING & ROBERTSON, INC.

W. H. Vogelsang, Director
Foundation Investigation

WHV/dw

APPENDIX VI

EMBANKMENT CONSTRUCTION SPECIFICATIONS

The holding pond shall be graded and sloped as shown on drawings. The surrounding embankment shall be of similar material as specified for Zone #2, as specified below. No stumps or rock boulders that will interfere with seining operations shall be left within the limits of the holding pond.

All borrow pits shall be graded to prevent the ponding of water. Banks of borrow pits outside the area to be inundated, and banks of spillway, shall be left on uniform smooth slopes, or as shown and directed.

4. FILL OR EMBANKMENT:

Material removed from the core wall, if suitable, may be placed to form the downstream toe of the earth-fill dam. This material shall be placed in 6-inch layers and worked over with a bulldozer and compacted by sheep-foot roller. The sheep-foot roller used throughout the work shall provide a unit pressure of 450 lbs. per sq. inch for that portion of the roller in contact with the fill material. It is the intent of this specification to obtain a fill compacted to not less than 100% of the maximum density, as referred to in AASHOT-99, at optium moisture content. The Contractor shall therefore add moisture, or dry by aeration, each layer as may be necessary to bring the fill material to optium moisture content for compaction.

Before starting on the fill proper, the area to be covered shall be carefully inspected for pockets of muck or other unstable foundation material. All such unsuitable material shall be removed. It is the intent of this specification to obtain a foundation that will safely support the fill to be placed, without give or subsidence.

The fill shall be slightly sloped from the center, downward to the edges, during construction to prevent the ponding of water. The fill proper shall be constructed in the following three zones, all of which shall be brought up uniformly and be well knitted together.

Zone #1 shall consist of the central portion of the dam forming a trapezoid measuring 8-ft. wide at the top with sides sloping 1-ft. horizontal to 5-ft. vertical to the subgrade of the core wall, as shown. This zone, together with the core wall, shall consist of the best clay available from the site. No solid rock, measuring more than 3-inches in diameter, shall be allowed in this zone.

Zone #2 is the fill extending from Zone #1 to the upstream face of the dam. This zone #2 shall consist of the second best clay available from the site and rock larger than 6-inches diameter shall not be allowed.

Zone #3 includes the fill from Zone #1 to the downstream face of the dam. This zone may be composed of material unsuitable for either zone 1 or 2 but shall be deposited and compacted in layers as specified for other zones of the dam.

All earth used in making the embankment shall be clean clay, free from roots, top soil, or other objectionable materials. It shall be taken from the area to be inundated, and the area to be deepened near the upper end of the pond, as indicated on the plans. The first layer deposited on the area to be covered by the dam and embankment around the holding pond shall be spread to a thickness of approximately 3-inches and rolled with the sheep-foot roller to penetrate into the subgrade and form a bond between the two materials. Successive layers shall not be over 6-inches in thickness before compaction.

Should soft spots be found in the fill, they shall be removed and the area covered recompacted.

The use of frozen material in embankments will not be permitted, and no fills shall be placed on frozen ground.

Should other areas have to be brought up to grade by fills, such fills that will support paving or structures shall be formed of selected clay and be compacted in 6-inch layers, ahead of grading operations.

At such times as the Engineer may direct, the Contractor shall have the fill checked for compaction density by Froehling & Robertson, testing agents, of Richmond, Virginia, or other approved testing agent. Three compaction tests shall be made during the progress of the work, the cost of same shall be borne by the Contractor.

5. PARKING LOT IMPROVEMENTS:

The parking lot shall be cleared of all unmarked trees, all stumps, brush, etc. within limits shown. Grading shall be held to a minimum and in general shall consist of smoothing or sloping the site with bulldozer or blade grader.

Unmarked trees, stumps, etc. within the area of parking spaces shall be cut not higher than 2-inches above ground. Cutoffs shall be level to prevent tire punctures. Brush shall be cut off below ground level. Marked trees shall be protected against damage during grading operations.

Oak from 6-inches to 9-inches diameter, taken from areas to be cleared, shall have bark removed and shall be placed in front of all tiers of parking spaces, as shown. Secure in place by 2" x 4" oak stobs, set on each side of stop-logs at 6-ft.. centers, pointed, and driven securely. Stop-logs shall be set on 6-inch concrete blocks, 8" x 8" in plan, at approx. 6-ft. centers, with #9 wore ties on top. Stobs after pointing, shall be of seasoned oak, and soaked in creosote for a period of not less than 12-hours before driving.

Cover parking area with #7 crushed stone (State Highway Specifications) to a minimum thickness of 3-inches and leave surface smooth.

APPENDIX VII

LETTER FROM OWNER

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1WG.

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JAMES D. BOWIE, VICE CHAIRMAN
BOX 1078, BRISTOL 24201
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COMMONWEALTH of VIRGINIA

COMMISSION OF GAME AND INLAND FISHERIES
Box 11104
Richmond, 23230

JAMES F. McINTEER, JR., EXECUTIVE DIRECTOR
4010 WEST BROAD STREET
BOX 11104
RICHMOND 23230

August 30, 1979



Mr. R. V. Davis
Executive Secretary
State Water Control Board
P. O. Box 11143
Richmond, VA 23230

Dear Mr. Davis:

Our staff has reviewed the preliminary Phase I Inspection Report for Lake Robertson dam and are in concurrence with the findings and recommendations.

Efforts are currently underway to secure funding for the proposed testing and subsequent corrective measures.

Sincerely,

Larry G. Hart

Larry G. Hart, Chief
Lands and Engineering Division

LGH/sk
cc: Mr. James F. McInteer, Jr.
Mr. J. W. Engle, Jr.
Mr. Jack M. Hoffman

APPENDIX VIII

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